FACTORY MANAGEMENT

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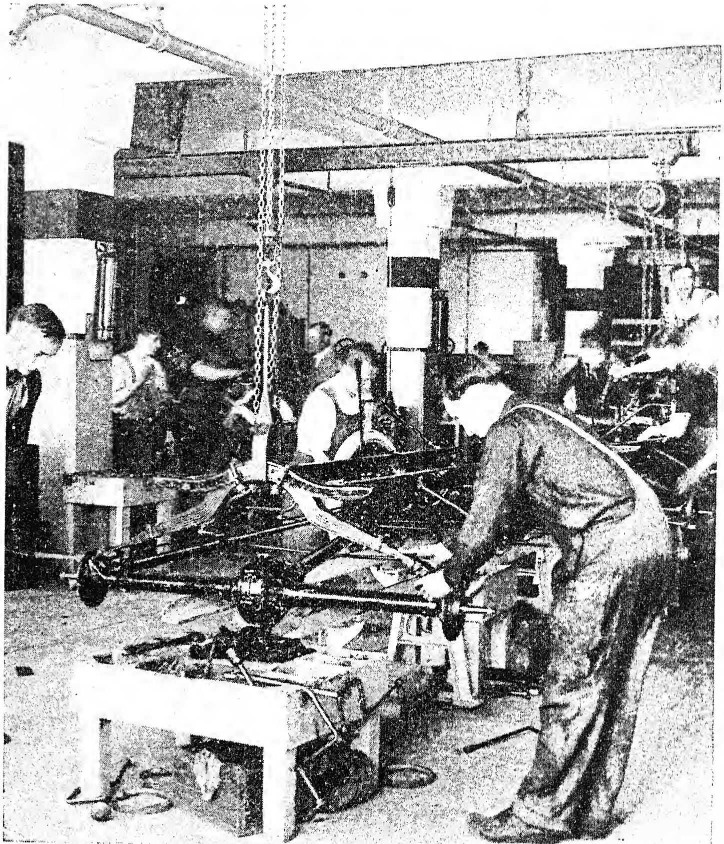

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Fig. 1.

AUTOMOBILE ASSEMBLY

FACTORY MANAGEMENT

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New York
THE MACMILLAN COMPANY
1930

Set up and electrotyped. Published March, 1924.

· PRINTED IN THE UNITED STATES OF AMERICA ·

PREFACE

There are various points of view from which a factory may be studied and described. To the manager, the engineer, the accountant, the economist, the working man—to each of these the factory is a problem seen from a particular angle, and a problem large enough to warrant voluminous treatment from the one point of view. In the present volume it has been the author's purpose to give as nearly as might be a balanced description of the operation of the various departments of the factory, to show their relation to each other and their problems as part of the greater problem of coördinating all activities of the organization toward the accomplishment of the single general purpose. In the author's teaching experience he has found that probably the best fashion in which to present a picture of the factory as a working organism is through the study of the problem of production control, and an attempt has therefore been made to gather up the various methods and theories on this subject into a somewhat connected philosophy of control.

Throughout the book an attempt has also been made to present the point of view of the owner and manager as well as that of the specialist. W. L. George has called the business man the great compromiser, and it is certainly true that where the student and the specialist are interested in the logical completeness and comprehensiveness of a system, the owner and entrepreneur is less interested in perfection of form than in effectiveness and economy of results.

Naturally in a book covering so wide a field as this, the author must acknowledge indebtedness to the ideas of many men. In common with the industrial engineering world he recognizes his debt to Frederick W. Taylor and to the little

group of engineers who with Taylor made such notable contributions to the study of industrial management. The assistance of Professors Walter E. Lagerquist, Fred E. Clark, and Eric L. Kohler in reading portions of the book and offering valuable suggestions for its improvement is gratefully acknowledged. It is a particular pleasure here to record my gratitude to Carl G. Barth, under whose kindly and stimulating direction the writer served his apprenticeship in organization work.

H. P. D.

CHICAGO, ILLINOIS.
JANUARY, 1924.

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CHAPTER I

THE FUNCTIONS OF THE FACTORY

A SMALL-TOWN druggist conceived the idea of a new style of sick-room fumigator, vaporizing formaldehyde in a simple and convenient tin candle. He bought the tin vaporizers and in a room above his corner drug store filled them with the preparation during odd times. The fumigator took hold of public favor and other lines were added. From this simple beginning arose a manufacturing and jobbing druggist's specialties industry, distributing its varied products nationally and equipped with its own extensive factory and sales organization.

Most factories arise from similar simple beginnings, either the small shop which by successful enterprise has expanded, or an organization in which men with previous experience in small things are able to start immediately on a larger scale. Looking at the successful factory one is always tempted to speculate as to just why it succeeded where so many others failed, just what are the essential factors in its success. And it is often singularly difficult, even for the proprietor himself, to put one's finger on the elusive something which has proven the magic touchstone. Yet we may name some of the conditions and qualities which in general often do contribute, singly or in combination, to the growth of an industrial organization.

In the case of the druggist mentioned the initial start which

enabled him to forge ahead of the rank and file was the novelty of his idea. Such ideas may be merely chance discoveries, or they may more likely be the result of a patient and systematic investigation. In any case, and for any type of successful novelty, whether of design or method of manufacture, of distribution or of adaptation to new uses, the effect of the novelty is to give a temporary monopoly advantage to the owner, which enables him to reap the profits which provide for further expansion. The "Eversharp" pencil is another interesting illustration. Other magazine pencils had been made for years, and apparently the Eversharp manufacturers were not able to secure patents basic enough permanently to retain the field, yet the fact that their pencil was the first to capture popular fancy enabled them to accumulate resources and build a good will which must have proven a heavy handicap to other aspirants in the field.

Good judgment, character and determination, courage, initiative, persistence and others of the orthodox virtues are also important elements in success. The student of management is apt to forget that the methods of science and the details of system and organization are but tools, which strong men use to accomplish results which they desire. There are problems and controversial questions enough, in all conscience, in the internal administration of the factory, yet the real battleground of industry is often in the market, where set rules form a poor substitute for the personal qualities of the leader.

All of these qualities are to a degree the common possession of the successful business man in any line and any rank. Deficiencies may be supplied here and there by the choice of complementary subordinates or associates, yet if the executive lacks many of these powers, leadership will pass from his hands to those of another.

Turning again to the factory we find a more special group of qualities, more easily found in subordinates. Technical ability and knowledge are necessary in the design of product

and the conduct of process. Selling ability and technique must provide the vital outlet for the stream of production.

Another problem appears and makes its increasing demands for special ability as the factory emerges from the status of the small one-man concern. This is the problem of organization. In the small factory the instinctively systematic procedure of an orderly mind may well suffice to meet the organization problems of the business. The manager knows everything that is going on and is there to see that it goes right. Little more is needed. As the business grows the work is divided and functionalized so that no one subordinate sees this work in its entirety. Methods must be found for defining the bounds of activity and for coordinating the efforts of men so that their work will fit into the general scheme even though they may not themselves be fully aware of what this scheme is. We find thus a distinct problem in developing a correct structure of organization, and a special technique of system and operation. It is with this problem that this book will primarily deal, recognizing at the same time that factory organization and methods from this standpoint are only one, and sometimes a lesser one, of the daily problems of the executive. Factories often achieve large commercial success in spite of an almost total lack of sound organization, yet it is a success needlessly lessened by waste, a success at the mercy of any competitor who adds organizing to commercial ability.

Scientific Management.—Most men abstractly recognize that for every effect inexorably there is a cause, yet few in practice are willing to go to the trouble of thinking through to causes and general principles. In fact, in many commercial problems the cost of a thoroughgoing investigation and research into a particular problem might exceed any possible profit yielded by it. Confronted with this dispiriting fact, under the constant pressure for immediate profits and results, the business man has too often yielded to the temptation of not thinking or investigating at all, but of relying on tra-

ditional methods and policies or blind chance for his guidance. It has been left to the engineer to apply systematically in industrial problems the methods of science which yielded such rich results in the field of physics and chemistry. Frederick W. Taylor was the first to give comprehensive published recognition to the fact that the methods of analysis of science could be applied in manufacturing control, that the problem of production was an equation whose factors could be measured and for which a solution of greatest effectiveness could be found. Taylor's work and that of his associates developed many specific devices and methods of value in industrial practice, but of more importance was the spirit of patient and thorough study to which this work was a stimulus, a spirit which has developed the invaluable research method of operation analysis, discussed in Chapters V and VIII, and which has raised cost accounting, production control, personnel and sales management from the status of largely empirical arts to that of definite and well understood means of control.

Studying the factory in operation, and particularly, comparing various types of factories, one is struck by certain basic similarities and problems common to all manufacturing of whatever type, and he begins to perceive certain lines of classification by which certain factories externally very different are found to be susceptible to the same general treatment. Following with some modifications the classification proposed by A. H. Church in his book "The Science and Practice of Management," we will at this point attempt a general classification of the functions of production. In Chapters II and III the general functions of finance and sales will be discussed in their relation to production, and in Chapter IV we will return to a classification of the various types of factory problem.

The Functions of Production.—Examining the structure of the factory organization we find that it, like other business, has first the two great functions of production and of sale, with the auxiliary functions of general administrative control

and leadership, of finance, and of record making and accounting. Concerning ourselves more particularly with production, all of the operations and functions involved in producing an article in the factory may be grouped into four fundamental types: **design, supply, control,** and **operation.**

THE FUNCTIONS OF PRODUCTION

1. *Design.*
   a. Of product—Engineering Department.
   b. Of process—Routing, Time Study, Planning Departments.
   c. Of operating methods—Methods or Efficiency Department.
   d. Of tools—Tool Design Department.
   e. Of selling methods—Advertising and Sales Research Departments.
   f. Of policy—General executives.

2. *Supply.*
   a. Of money—Treasurer's Department.
   b. Of materials—Purchasing, Receiving, Stores, Traffic, Shipping Departments.
   c. Of equipment—Purchasing, Tool, Maintenance and Plant Engineering Departments.
   d. Of men—Personnel Department.

3. *Control.*
   a. Of administration and policies—Board of Directors, general executives.
   b. Of sales—Sales Manager, Credit Manager.
   c. Of expenditures—Auditor.
   d. Of operating program—Planning, Dispatching, Follow-up Departments.
   e. Of operation and discipline—Superintendent, foremen.
   f. Of quality—Inspection Department.
   g. Records as a basis for control are furnished by
      (1) Accounting Department.
      (2) Statistical Department.

4. *Operation.*
   a. Selling—Salesmen, Advertising men.
   b. Operation—The great body of workmen and mechanics.
   c. Clerical—Clerks and minor executives.

FIG. 2.

Design.—Take an automobile factory as an illustration. The first step in production is the design of some sort of a car, of a *product,* and we find an engineering department which is constantly gathering and trying out new features of design. In a chemical industry a laboratory would perform this function, in a tailor shop the designer or style man. Sometimes in a repetitive factory the design is made up once for all, but always provision must be made or has once been made for this function. The *method of making* the product must also be designed. This work is done by the route clerk or operation layout engineer. Suitable *tools* and fixtures and special machines must be worked out by the tool design department to carry out the production process and the time for manufacture must be estimated as a basis for planning. All of these are design functions, which may be performed quite independently of the act of production. Design problems also arise in connection with the laying out of organization and system, and in the field of sales management.

Supply.—To make an automobile, castings, forgings, steel, lumber, fabric, upholstering materials, glass, and a multitude of special parts, accessories, etc., must be purchased, and this function of supply of *materials* is taken care of by the purchasing, receiving, stores, and material move departments. Money must be forthcoming in stated amounts to meet payrolls and bills payable, and one of the higher officials, usually the treasurer, sometimes the president or other official, is made responsible for planning and arranging for the supply of *money or credit. Tools and equipment* must be supplied. Usually these are secured by a buyer in the purchasing department, on recommendation of the superintendent or of a special equipment committee. And finally *workmen* must be secured, trained, and made effective members of the organization—the function of a personnel or employment department. In each of these supply functions we distinguish first the securing of the materials, money, or men, second the maintenance and care of the elements secured—accounting,

protection from deterioration, repair of damages, in the care of materials and money, and the special duties involved in the care and development of an organization of men and women.

Control.—Control is the third function. We have a design, and the materials, machinery and men stand ready. For their effective combination to produce a product we need a system, first for issuing orders, secondly for seeing that these orders are carried out and for inspecting the results. If we turn to the automobile factory we will find in it some form of *planning* department, which takes the standard times and production plans of the manufacturing design and transforms them into a detailed schedule, with each machine's or department's work so timed and proportioned that all will come out together and in the right quantities to produce the finished car. We will find also an organization responsible for the *supervision* of the men as they carry out these orders. This organization, sometimes called the "old line" part of the organization to distinguish it from the newer functional planning departments, includes the superintendents, foremen and gang bosses who are directly responsible for the performance and discipline of the men, who instruct them in their work, and in general reinforce and make effective the schedule of the planning department. An *inspection* department is necessary, in order to assure a control of quality. The *managing executive* himself performs an important part of the control function.

In order to profit by experience and to guide in many ways in making decisions, we need *information* of various sorts, brought to the executive who exercises the final control function, in such form that it gives him a clear picture of what is happening and of the factors which must be considered in deciding. There is therefore present in the factory as an auxiliary to the control departments a group of departments whose function it is to gather information, digest it, and present it in the form of records and summaries to the various executives concerned. The accounting organization is the chief

of the information services, with its statements of financial condition, of costs and results of operation, but various other summaries are made of the activities of the various departments and officials, such as a record of orders filled on time, of bonus or piece rates earned, of imperfect work, and of many other items of importance.

Operation.—Operation is the largest, in point of number employed, of the four functions. Out of ten people employed by the factory perhaps one will be employed in general administrative and sales work. One or two will be employed in shop administration and supervision. The remaining seven or eight will be direct producers as machinists or other workmen. These proportions of course differ widely in differing cases. Sometimes only one or two out of a hundred will be engaged in the indirect and auxiliary functions; at times there may be more salesmen, office people, etc., than there are workmen.

This description gives some sort of a picture of the functions of the factory. The actual organization will follow this outline in a broad way, but various considerations of convenience, of the need for check by one department on the activities of another, and similar considerations affect the actual organization materially. Thus, operation analysis is theoretically in the same family with engineering, but because of its need for intimate day-to-day contact with scheduling and shop operations this department is often put with scheduling and follow-up, in a general shop planning department. Stores and purchasing are closely related in theory, but are separated to provide a check on possible irregularities in the handling of materials. Inspection may be classified as a control function, although final inspection is frequently supervised by the engineering department to remove it from the pressure of the operating departments. Record keeping may be handled by one accounting and statistical department but is quite as likely to be broken up among small groups attached to the appropriate departments.

- Stockholders
- Board of Directors
  - President
    - Vice President in Charge of Accounting
        - Auditing
    - Vice President in Charge of Sales
        - Contracts
        - Credit Department
      - Merchandise Manager
        - Warehouse Stocks
        - Service to Customer
        - Accounting, billing, claims
      - District Sales Manager
      - Advertising Department
    - Treasurer
    - Secretary
      - Legal Department
    - Vice President in Charge of Engineering
    - Vice President in Charge of Purchasing
    - Vice President in Charge of Manufacturing
      - Manufacturing Committee
      - Production Superintendent
          - Shop Methods
            - Drafting and Blue Printing
            - Operation Planning
              - Machine Analysis
              - Layout and Capacity
              - Tool Planning
            - Premium and Piece Work Rates
          - Material Orders and Records
            - Schedules
            - Stock Keeping and Material Handling
          - Dispatching
            - Tracing
          - Employment
          - Operating
            - General Foremen
              - Section Foremen
            - Inspection
            - Shop Clerical
            - Cost
              - Payroll
            - Accounting
            - Office Service
          - Plant Service
            - Construction Engineer
            - Service, Janitor, etc.
            - Protection
          - Methods and Betterment Department

FIG. 3.

A TYPICAL FACTORY ORGANIZATION.

Two diagrams are given below which illustrate the typical organization and departments found in good-sized manufacturing companies. In these diagrams, officers and department heads of the same rank are shown in the same line vertically, while those of subordinate rank are inset toward the right.

FIG. 4.

ORGANIZATION OF A LARGE MOTOR FACTORY
TWO PLANTS, EACH ABOUT 5,000 MEN.

- President and General Manager
  - Secretary
  - Counsel
  - Vice President and Manufacturing Engineer
    - (1) Vice President in charge of Finance and Accounts
    - (2) Vice President in charge of Sales
    - (3) Vice President and Chief Engineer
    - (4) Production Manager
    - (5) Factory Manager, Plant A
    - (6) Factory Manager, Plant B
    - (7) Manager of Inspection.

The details of organization of these departments are charted below. The work of vice-presidents (2) and (3), while of great importance, is small in volume and these men require few assistants.

- (1) Vice President in charge of Finance and Accounts.
  - (a) Treasurer
    - Comptroller
      - Factory accountant, Plant A
        - Timekeeper
        - Payroll and labor distribution
        - Costs
        - Factory bookkeeping
      - Factory accountant, Plant B.
- (4) Production Manager
  - (a) Chief of planning and scheduling, Plant A.
    - General dispatcher
    - Shortage dispatcher
    - Material follow-up
    - Engineering follow-up
    - Shop follow-up
    - Dispatcher of service and shipping

Fig. 4.—Continued

(b) Chief of planning and scheduling, Plant B.
(c) Purchasing agent
    Chief buyer
    Buyers
    Purchased parts follow-up
    Traffic manager
(d) Labor Manager
    Employment department
        Employment office help
        Instruction department
        Restaurant
        Welfare
        Tool check-room
(e) Materials Manager
    General storekeeper
        Rough stock foreman
        Finished stock foreman
        Receiving clerk
        Order clerk
        Record clerk
(f) Tool Development Supervision
    Production engineer
    Operation layout
    Tool design
    Gauge design
    Machine layout
    Time study and demonstration
    Chief clerk
        Scheduling
        Follow-up
        Records
(g) Powerhouse Chief Engineer
(h) Plant protection department
(i) System and methods department
(j) Garage department.

(5) Factory Manager, Plant A
    Assistant factory manager
    (a) Superintendent machine shop
        Foreman, automatic lathe department
        Foreman, crank shaft and cam shaft
        Foreman, heat treatment
        Foreman, punch presses
        Foreman, blacksmith
        Foreman, electrical
        Foreman, crank case and cylinder
        Foreman, connecting rod and piston
        Foreman, screw machine
        Foreman, yard labor

Fig. 4.—Continued

Foreman, of equipment
Trucking
Shop orderly
Janitors and sweepers
(b) Tool construction superintendent
Chief clerk
Tool dispatching and follow-up
General foreman, tool room
Chief tool inspector.

(6) Factory Manager, Plant B.
(Organization similar to 5.)

(7) Quality Managers
(a) Chief Inspector, Plant A.
Assistant chief inspector
Inspector foreman, rough stock
Inspector foreman, receiving
Inspector foreman, machine shop
Inspector foreman, assembly
Metallurgical laboratory
Salvage department
(b) Chief inspector, Plant B.
(Organization similar to 7a.)

CHAPTER II

FINANCING

Every operation in manufacture and distribution requires capital, and the securing and regulation of the flow of this capital constitute a problem which requires more accurate solution the greater the volume of business done on a given investment and the more rapid the growth of the business. It is important to the man concerned in factory management that he shall see clearly the financial implications of the various operations of the factory.

Organizing the Business.—The initial impetus for a successful factory comes frequently from a new idea such as that of the fumigator mentioned in Chapter I. Or a salesman or other employee of an existing company, feeling that he has mastered the business and seeing an opportunity, may gather about him a suitable organization and start a new business. Sometimes a business, started as a small local mechanic's or service proposition, grows to the point where a larger organization is needed. In any case, either at the inception of the business or at some point in its expansion, there is likely to come a time when the owner's resources prove inadequate and he must secure additional funds, either from men who take a share in the business, or as a loan.

The Corporation.—The usual procedure in inducing others to share in the business is to organize a company, most frequently a corporation, and to sell shares in this company. In organizing a corporation, application is made for a charter to the secretary of state of the state in which incorporation is to be effected, the application setting forth the purpose and desired period of life, within statutory limits, of the corporation, the names of the applicants for the charter, the amount

already subscribed to the capital, the total capitalization and other information. If the application is approved a charter is then granted, an organization meeting is held, by-laws are adopted and a board of directors is elected. This board thereafter represents the stockholders in all transactions, the stockholders having no right, as such, to act as agents in binding the company to any contract or in any other matter.

Capital Stock.—Ownership in the corporation is represented by shares of stock, usually but not always having a fixed par value, as one hundred dollars. Each share represents a definite proportion of the actual worth of the company, whatever that may be at any time. Liability of the shareholder for debt of the corporation is limited except in two states, and for mechanics' liens to the amount of the original subscription. Shares are transferable at will, the transfer being recorded in the books of the company. Dividends may be declared by the directors when a surplus is available for distribution but are not a legal liability of the company until so declared.

Classes of Stock.—There are several classes of representation of ownership by stocks which may be employed. *Common* stock represents pro rata participation by the owner of the stock in the control and profits of the company, no preference being given it. It carries the right to vote in the election of directors and other business coming before meetings of stockholders. *Preferred* stock is of many varieties, some of the common preferences being as follows: Preference as to dividends, the preferred stockholder being entitled to a fixed percentage before any dividends are declared to common stockholders. In cumulative preferred stock this preference applies not only to the division of the current year but to all unpaid preferred dividends of previous years at the fixed rate, which must be paid before the common stock participates. Sometimes the preferred stock is also *participating*, sharing equally or in an agreed ratio with common stock in any surplus available after each has been paid an agreed rate. Preferred stock may also be preferred as to assets, in which case, if the com-

pany goes out of business, or fails, and its assets are disposed of, the claims of preferred stockholders must be satisfied, after reimbursing creditors, before any division is made to common stock. In return for these preferences, preferred stock seldom carries the right to vote, thus leaving control with common stockholders. A decision of the Illinois courts makes it illegal to deny the right to vote to preferred stock in that state.

Modified Corporation Forms.—The *holding corporation* is organized to hold the shares of another or of other corporations, not itself engaging usually in the activities of production and sale. The *Voting Trust* is an agreement by which shareholders of a company surrender their stock for a fixed period and with fixed restrictions to a trustee or group of trustees, receiving in turn trust certificates. The trustees are then free for the period to administer the business without fear of reversal of action by the stockholders. The latter receive their dividends as they may be declared by the trustees.

The Partnership.—In the partnership no legal authorization is necessary to conduct business. Two or more individuals draw up a partnership agreement covering contributions of capital and services, rights and duties of the respective partners, payment for services and division of profits, and similar matters. They are then ready to commence business. Each partner is liable jointly with the others, or alone if the others have no collectible assets, for all debts of the partnership. Each partner is empowered to act as agent of the partnership, and although this power may be limited for a partner by the partnership agreement a contract entered into by an outside party in good faith with such a partner will be binding on the partnership. Shares are not transferable except by entering into a new agreement. Death or withdrawal of a member thus automatically terminates the partnership. It is a less flexible form of ownership than the corporation.

The Association under Deed of Trust.—This form is one somewhat less commonly used, but possesses advantages, like the partnership, in its exemption from some of the numerous

taxes and fees which of late years burden the corporation. It is also used to hold title to land in those states in which corporations are restricted in this right. With this form the owners of property execute a deed of trust, appointing trustees who administer the estate or property independently of the instructions of the owners.

Borrowed Funds.—The sale of stock is the common expedient for raising money for a new and untried company, since few investors care to loan money to a new company without the chance of profits larger than the usual rate of interest. As the company becomes established, however, it becomes increasingly easy to borrow for many of its financial needs. Industrial loans may be classified somewhat loosely according to the length of time for which the money is borrowed.

Bonds.—Where the loan is for a long period, as where new machinery or new buildings are purchased with the expectation of paying for them later out of profits, it is usual to raise money by the sale of bonds. A series of bonds is issued and specific items of property or in some cases the general assets of the company are pledged as security for payment and the fulfillment of the conditions of the loan. A trustee is appointed to act for the bondholders in foreclosure or other suitable action in case of default by the borrowers in payment of principal or interest or observance of the terms of the agreement.

Notes.—Where the loan is for shorter periods it is possible frequently to raise money by the sale of notes. These may be sold to or by investment note brokers who specialize in this type of paper, and this is a usual method of borrowing any considerable sum for periods of from one to five years.

Bank Loans.—For the short-term needs of a few months, incidental to the seasonal fluctuations of the business and for similar short-term needs, assistance is usually secured from the commercial banks. The borrower will discount a sixty or ninety day note at the bank, and perhaps renew it when it

falls due. The bank expects the borrower to maintain an average deposit equal to about one fourth of the amount of the loan, and it is usual to expect the borrower to clean up his notes at least once a year in full. One of the first steps in starting any business is to establish a line of credit at one or more banks, giving the bank a statement showing the financial condition and net worth of the business, and arranging for the securing of credit as needed up to a specified limit. It is important that the company's credit be carefully safeguarded by prompt meeting of obligations and conformity to the established usages of business.

Credit is also sometimes secured by giving notes to suppliers of merchandise or by securing long terms of payment from these vendors. The resourceful financial director of the company will anticipate from month to month the money needs of the business and will at all times know where to lay his hands on additional reserve funds in an emergency. In any business of considerable size it is desirable to maintain regular relations with several sources of borrowed funds, to have checking accounts and make loans with two or more banks and to keep in touch with investment houses.

Acceptances.—A modified form of note borrowing which is coming into use is the discounting of trade acceptances. The manufacturer arranges with his customer to draw a draft on the latter for the amount of the invoice shipped. This draft is sent with the invoice to the customer and accepted by him payable at a specified date, say thirty, sixty or ninety days later. This accepted draft or acceptance, bearing the endorsement of both parties and in itself the evidence of a current transaction, is generally regarded as prime commercial paper and may be rediscounted by the bankers with the federal reserve banks.

Working Capital.—In addition to the investment in plant and fixed assets there is a large investment in such items as raw materials, money expended for labor and general expenses, goods in transit or delivered to customers but not paid for,

and similar items which constitute what is known as the working capital of the plant. While this investment is constantly being converted into money by the payment of customers' accounts, fresh funds are as constantly being put into it, so that there is continuously a large sum tied up and unavailable for use. The amount required for this purpose will vary from week to week according to the payments and receipts of the company.

Various factors affect the proportions of capital necessary as working capital. Length of process is one. In some types of tanning, the hides may be in process for over a year, while in the packing of meat the animal is purchased one day and some parts of the meat from it may be sold within forty-eight hours. The credit terms of sale and purchase also exert a large influence on the amount of working capital required. At times in certain businesses of a seasonal nature, from a half to three quarters of the total capital may be in the form of accounts receivable. On the other hand certain firms which buy on long and favorable credit terms and sell virtually for cash may continually have the use of substantial sums for which they pay no interest.

More working capital is required in a seasonal business than in one with a comparatively steady demand. Uncertainties of the buying market which make it necessary to carry larger stock of raw materials affect working capital unfavorably. Figure 5 illustrates the distribution of assets and the capital turnover in several large manufacturing companies.

A common mistake made in the initial financing of a business is a failure to provide enough capital, not only to purchase the plant, machinery, and other fixed assets, but also to provide for working capital and for the inevitable losses and mistakes of the initial period. For a considerable period even after the factory has started operations, money will constantly be required for payrolls, the purchase of materials, etc., in greater amounts than it will be received from sales,

Case Number	*1*	*2*	*3*	*4*	*5*	*6*
Nature of Business	*Automobile Manufacturers*			*Meat Packer*	*Steel*	*Farm Machinery*
	"A"	*"B"*	*"C"*			
	%	%	%	%	%	%
Assets:						
Real estate and plant	57	35	3	58	115	39
Sundry investments	16	1	..	25	5	3
Deferred charges	1	..	4	..	4	..
Good will, patents	6	..	69	..	..	..
Total fixed assets	80	36	76	83	124	42
Cash	10	13	1	13	1	3
Accounts, bills receivable	8	22	6	77	5	28
Inventories	30	39	27	39	18	52
Marketable securities	..	2	..	13	9	..
Total quick assets	48	76	34	142	33	83
Total assets	128	112	110	225	157	125
Liabilities and Capital:						
Capital stock	84	41	35	70	61	72
Surplus	16	59	65	30	39	28
Net worth in thousands of dollars (equals 100%)	367,657	16,735	6,571	214,158	1,428,810	213,877
Funded debt	1	..	..	54	40	..
Reserves and accruals	10	1	..	3	15	11
Accounts and bills payable	17	11	10	68	2	14
Total indebtedness	28	12	10	125	57	25
Annual sales	83	255	53	280	69	57

FIG. 5.

RELATIVE DISTRIBUTION OF ASSETS IN REPRESENTATIVE LARGE COMPANIES, IN TERMS OF PERCENTAGES OF NET WORTH.

and many a venture has been shipwrecked by a failure adequately to anticipate these needs.

Turnover.—Since a profit can be earned each time an article passes through the production process and is sold, and since the number of articles in process at any one time is very definitely limited by the capital capacity of the company, it follows that an important problem in management is that of increasing the rapidity of this movement, which may be measured in terms of capital turnover, or the ratio of annual sales to capitalization, or of stock turnover, the ratio of the annual or periodical sales to the average stock inventory for the period. One of the problems of the storekeeper and purchasing agent is that of keeping the inventory at the lowest figure consistent with uninterrupted production, and one of the important reasons for an effective system of production control is the time saved by such a system in moving material through the productive process.

Circulation of Capital.—A clear picture of the circulation of capital may be given diagrammatically as in Figure 6.

Money is initially put into the business as cash for the most part, which is spent, part of it reappearing in the form of buildings, equipment, material and other assets. Certain of these expenses really represent a direct loss, as when money is spent on an experimental development which does not prove practicable. Such losses are occurring all along the way, in waste of materials and in misdirected or idle labor, in bad debt losses, in accumulation of unsalable or unprofitable goods, and in a variety of other forms whose prevention and reduction constitute a formidable task of management. Some leakage is inevitable, however, and these leakages from the circulating medium of capital must be made up if the business is to continue to exist and to pay dividends.

It is possible to carry the analogy still farther, and to indicate the valves which regulate the conversion of capital from one reservoir to the next, such as the expenditure authorization, purchase and production order, time card, shipping

order, and the final check in payment by the customer. The application of motive power may also be indicated, at the point of sale where the pump of selling effort starts in motion

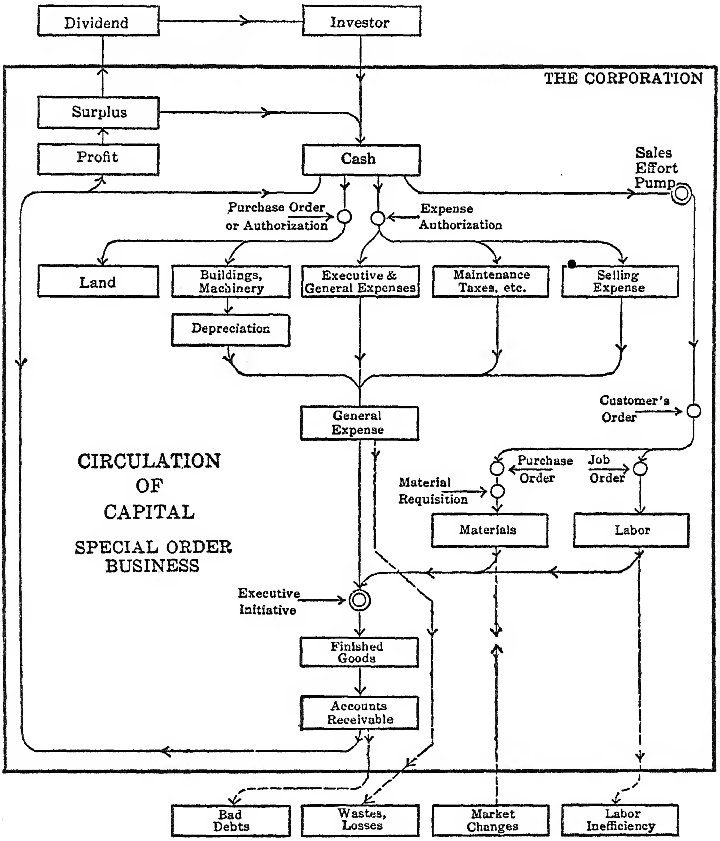

FIG. 6.

the flow of orders, and at the point of executive control of manufacturing where another motive application of executive orders and initiative overcomes the pressure of manufacturing difficulties.

The problem of financial and executive control is that first of supplying motive power to keep the pumps operating and second of regulating the flow so as to keep the business in balance. Too great selling pressure may result in clogging the valves of production so that hasty, careless production and confusion seriously increase the cost of production. Too sudden an increase of sales may also have the effect of tying up most of the capital of the business in one reservoir, so that it is unavailable to meet other demands. Thus sales in a year for a particular business will often be four or more times its entire capitalization. The figure for this capital turnover varies greatly, being influenced by length of process and other factors to be named later. It would not be uncommon to find that on the average a particular business would constantly have on its books, customers' accounts receivable equal to one or two months' sales—this factor, of course, being controlled by the credit customs of the trade and credit methods of the firm. Under these assumed conditions, with a capital turnover of four, and accounts receivable approximately equal to an average month's business, one third of the capital of the company would evidently be tied up in accounts receivable—not at all an extraordinary figure for an active business. A sales effort which doubled the sales for some particular period would mean that for the duration of the period two thirds of the assets of the company would be tied up and unavailable. Prosperity of this sort might wreck the business (and has often wrecked a business) unless arrangements had been made to secure additional capital when it was needed.

Seasonal Fluctuations.—Demand is relatively steady the year round in certain lines such as telephone service, the supplying of mixed industrial power load by an electric central station, or the baking of bread. But in a majority of industries there are one or more seasons of activity, followed by seasons of inactivity, of sale or manufacture. Thus beet sugar, sold the year round, in this country is manufactured

entirely in the four or five months from October on, the plant being practically closed the rest of the season. Tailoring has busy seasons in the spring and fall, occupying from eight to ten or eleven months of the year, with one, two, three, or more idle months, dependent on the prosperity of the season. Building activities are heaviest in the spring, summer and fall, and steel, cement, lumber and other industries which serve building adjust their seasons accordingly. Spring is the heavy season in the automobile trade, spring and fall for the furniture trade. Novelties, gifts, phonographs, Christmas cards, and similar articles are in heaviest demand just before the holidays, and in some of these lines practically the whole season is compressed into the two or three months just before Christmas.

Adjustment of Production.—The adjustment of production to such widely fluctuating demands introduces a variety of special problems. An effective and humane labor policy indicates steady employment, and the lowest manufacturing costs and most effective use of equipment are secured where production can be regularized by making up stock during the dull season. In fact, it is usually necessary to keep salesmen, executives, and the better grade of workmen employed fairly steadily if they are to be retained at all. On the other hand, manufacture of stock imposes serious strains on working capital, and a risk of market or price changes which must be carefully considered.

Faced with this dilemma the manufacturer resorts to a variety of expedients. In the first place, that portion of the peak load which is unavoidable is carefully planned for in advance. Arrangement is made by terms of purchase, maturity of loans from the banks, etc., to carry as many as possible of the obligations incurred, over into the later period of return of investment. Probable money needs are gone over with an official of the bank, who soon learns the season of heavy demand in the business and is willing to aid in carrying its burdens. And provisions are made for recruiting a

temporary crew to help out at the peak, for a supply of materials and for contracting out those parts of the work which can not be done with the company's equipment.

In the second place an effort is directed toward distributing the load. One of the widely used methods is diversification of demand or the combination of industries having complementary seasons. Thus a manufacturer of automobile cushion springs used his machinery and crew of wire workers in the autumn to produce wire lampshade frames. A printer employed his women operatives to wind radio coils during slack periods. A men's suit manufacturer added caps and raincoats to cover his dull season. A manufacturer of electric flatirons, most popular during hot summer weather, added electric percolators for which the sale was heaviest at Christmas. The great basic industries such as steel are kept constantly busy during normal times by the successive demands for structural steel, automobile, agricultural implement, and other trade needs.

Another method of securing diversification is by seeking other markets. Thus an agricultural implement manufacturer filled out the dull season in the Northern hemisphere by developing a trade with South America.

Relief is sometimes obtained by the cooperation of a group of manufacturers. Thus lumbering, harvesting crops, spring farm work to a limited extent, spring railway track work and the ice harvest furnish successive employment to a group of itinerant laborers who regularly move from one to another. A large department store, whose busy season came at Christmas, arranged to exchange part of its force with a printer of Christmas novelties, who needed help during July and August, the dull month for the store. Many industries in small towns draw in employes in the winter who work on farms during the summer month.

Fluctuations in demand may also be modified by advertising and other means of positive market control. The flatiron manufacturer mentioned also produced a sales peak in the

previously dull month of May by staging a salesman's competition during the month. Monday used to be the heavy day in laundries until a system of distributing calls throughout the week, calling on one group of customers always on Tuesdays, another on Wednesday, and so on, broke up the Monday habit. Other examples of the same method of control are the campaign for winter automobile driving, the reduced price for coal bought during the summer months, the "keep our tailors busy" sales of the tailors and the January white goods sales of the department stores.

The problem of regulating the circulation of capital within the business is not only affected by these regularly recurring seasonal changes but is complicated by market and style changes which can only be partially predicted. We are beginning to understand in part the nature of the economic cycle of alternate depression and expansion, but there are many minor movements and sudden changes which demand the best efforts of the executive to follow.

Barometers of Business.—Information as to the probability of such fluctuations is furnished the executive by the regular financial reports of stock and bond movements, material prices, Federal Reserve Bank transactions, summaries of exports and imports and reports of car movement, of steel tonnage, of crops and other basic factors. Often there is some specific industry whose fluctuations are particularly related to the industry being studied. Thus a good crop year influences the farm implement people vitally and a building boom means a busy season for furniture manufacturers.

Reports as to local conditions also come in regularly from the sales organization. Sometimes the company has its own financial reporting system. It is reported, for example, that the American Steel and Wire Company has a system of crop reports which will aid in predicting the market for the various wire products such as fencing and hay wire, largely used on the farm.

Budgets and Financial Planning.—One of the most im-

portant applications of the principles of standardization and planning has been in this field of financial planning for the business. After a company has been in operation long enough to have accumulated experience and standards which may be used as a basis of comparison, it is possible to map out with a reasonable degree of certainty, and for some time in advance, the approximate volume of business which may be expected from a given territory, or from a given sales effort, such as an advertising expenditure of a certain amount. It is possible also to translate this probable demand into terms of financial requirements. A new product or an increase in volume of output will mean, as shown by existing standards and experience, so many machines, so much more tied up for labor and the expenses of manufacture and sale, so much in accounts receivable and in various other forms.

This budget may be simply a brief rough estimate of the principal receipts and expenditures for the period or it may be a complete working schedule for the whole organization. In the latter case it will include for the financial department a monthly or periodical statement of income and outgo, including borrowed money. The financial budget is often set up in much the form of the usual profit and loss statement and balance sheet, differing only in that, in addition to the figures showing the results of past operations, parallel figures are shown item by item indicating the predicted results of future operations. To the purchasing agent an operating schedule will be furnished showing orders ahead or production planned by classes of product, which may be accompanied by definite schedules of requirements for each part and item to be purchased. The purchasing agent is thus enabled, knowing requirements well in advance, to place orders in time to ensure prompt delivery (an item of great practical importance) and is also given enough leeway to enable him to adapt his buying to favorable or unfavorable market conditions.

Sales and Advertising Quotas.—To the sales department the information contained in the budget will be furnished

as a definite quota, indicating the amount necessary to be sold of each line, in each territorial division, frequently by each salesman, and showing to the advertising department the appropriation available for each product or line of goods. The great advantage of a definite and coordinated plan in the expenditure of advertising funds is apparent. It makes it possible to use advertising as a flexible tool, to focus its effects at times or on lines where it is most needed. To the salesman and manager, also, the quota furnishes a month-by-month goal and measure of achievement.

In similar fashion the budget will be translated into units of output for the production department, and by this department will again be translated into terms of machine requirements, of number of men and of detailed plans and schedules for the period of the budget.

The degree of detail to which it is practicable to go in the use of the budget of course varies, being somewhat proportional to the exactness with which conditions may be foreseen and estimated. Only in a well-established business in which conditions had been carefully studied for some time would it be desirable to go to the expense of a complete analysis and fully detailed schedules. But in any business some sort of an estimate as a guide to expenditure is usually practicable.

The period covered by the estimate also varies. A plan often followed is to make an estimate in general terms for a year in advance, but to prepare the actual detailed estimates only for the coming quarter.

Figure 7 is a portion of a simple budget used in financial planning by a small business, which illustrates the principle and general method employed.

Uses of the Budget.—Once established, the budget becomes not only a guide to the current direction of operation but a standard of measurement and a check on changing conditions. Suppose that collections slow down, and the expected receipts from customers' accounts do not equal expectations for a period. In the first place it is asked, What is the reason? Is

BLANK MANUFACTURING COMPANY.

SUMMARY OF ESTIMATED EXPENSES AND INCOME FOR MONTH OF JANUARY, 19....

	Actual last year	*Estimated this year*	*Actual this year*	*Gain* over estimate	*Loss* over estimate
*Gross Sales	26,000	35,000			
Opening Balance ..	3,000	5,200			
Collections	32,600	36,000			
Received from loans	....	....			
Other Receipts....	1,000	....			
Total Receipts	36,600	41,200			
Steel	6,000	8,200			
Castings	2,500	2,800			
Purchased parts...	900	1,000			
Sundry Materials..	500	1,500			
Labor, Dept. A....	6,300	7,100			
Labor, Dept. B....	3,700	4,900			
Shop Supervision..	1,000	1,200			
Power, light, shop sundry	400	400			
Maintenance, repairs	800	800			
Total Manufacturing Expense	22,100	27,900			
Executive and Office Salaries.....	1,800	2,200			
Reserves for depreciation, taxes, etc.	1,000	1,200			
Rent	400	400			
Commissions and sales expenses...	2,400	3,000			
Advertising	1,200	2,000			
Total Operating Expenses	28,900	36,700			
Loans Paid	2,000	....			
Total Expenditure...	30,900	36,700			
Closing Balance...	5,700	4,500			

* Gross sales would be a total taken from a particularized sales budget constructed on the same plan as above, but giving the estimated sales for each territory and line or group of lines of goods made.

Fig. 7.

TYPICAL BUDGET FORM.

it a symptom of financial stringency in a district, which will presently reflect itself in reduced sales? Should we take measures to curtail production? Perhaps it is, on the contrary, an indication of expansion—the merchant who buys from us is selling so many goods that his own accounts receivable are becoming temporarily embarrassing. Again, the trouble may be in our own organization. Laxity in collections or carelessness in passing on credit of new customers may explain the discrepancy. In any case the budget, in addition to its function of a program of operation, gives a quick and sensitive indication of a change in conditions.

Typical Procedure.—The following is the general plan of procedure which has been in use for a long time by a large company. A sales estimate is made periodically and furnished to the manufacturing department as a guide in preparing for the expected demand, by the purchase of machinery or erection of buildings, development of special tools, placing material contracts and making of other preparations for which time is required. In the making of this estimate each salesman reports to his district manager the expected volume of sales for each important kind of product. The district manager summarizes and totals these reports, revising them in the light of his own judgment. These reports are in turn consolidated and revised by the general sales manager and gone over by him in conference with the executive committee, which includes general manager, sales and production managers, and financial man. This estimate, made several months in advance of the beginning of the six month period covered, is again gone over and corrected in the light of changed conditions, just before the commencement of that period. In this final stage it assumes the form of a general production schedule, and if loss is incurred through failure of sales to meet the schedule prepared for, it is charged, in the inter-departmental profit accounts, to the sales department.

A somewhat similar plan is supplemented in the case of a large clothing manufacturer by an elaborate analysis of sales,

which shows which models have proven popular, what each salesman has done in comparison with a previous period, and just what tendencies each section of the country shows as to style preference, sizes, and volume of demand. General economic and financial tendencies would also be carefully considered, and one of the various "business barometers" referred to in making sales estimates would be used.

Because of the uncertainties of the market, it is generally not advisable to make such an estimate for a longer period, or in greater detail, than is necessary to secure the more important economies of advance planning, nor to place orders or make preparations farther in advance than needful. Some firms do little estimating of this sort, meeting demand as it comes, and maintaining some excess equipment as a reserve. But such a policy usually means a condition of violent fluctuations of labor force, which is far more costly than the work of planning. Planning, while it may not fully prevent the effects of seasonal irregularity at least enables a partial preparation for it and smoothing out of the load curve.

The budget is capable of a further analysis which may shed additional light on tendencies of importance. It is possible, for example, to predetermine costs to a degree. In every establishment there are certain classes of charges, for rent, general supervision, heating, lighting, taxes, insurance, etc., which bear little or no relation to the volume of sales. There is another group of expenses which bears an indirect and partial relation to volume, such as clerical expense, detail supervision and administration, power, upkeep of machinery, etc. Some items which are in the first group in the small business fall in the second group with the large business. Thus selling expense is relatively fixed in many small businesses employing salaried salesmen, while in the large business or with commission salesmen it will correspond quite closely with the volume of sales.

Finally, there is a group of expenditures which is almost directly proportional to output. The expenditures for ma-

terials, a large part of the direct labor payroll, commissions paid to salesmen, etc., fall in this class.

Knowing these relations for the various classes of expenses, it is evidently possible to find the least volume at which business can be done at a profit, setting a danger signal which will give warning of approaching difficulty. It may be that the greater volume secured by a reduction in price might more than offset the direct loss of profit. It is also possible to approximately predict the profits for any given volume of business for which plans are being made.

Standard Ratios.—Other standards may be developed by which to judge the financial affairs of the business. Thus for any particular business there will be certain normal ratios which apply in various cases. Thus it may be the case that thirty or sixty days' business, on the average, is normally on the books as accounts receivable, this period (depending on credit customs) normally elapsing between sale and payment. This ratio will give a key to the financing of customers' accounts. Similarly, the company will normally experience a certain bad debt loss, varying from a small fraction of one percent up to two percent or more with certain classes of customers, one half of one percent probably representing an average maximum. Similarly, it is helpful for certain purposes to state the cost of materials, of direct labor, of various classes of overhead, of advertising and selling expenses, and of actual cash receipts, in terms of percentages of gross sales. Certain ratios, also, have been found safe as between quick assets (such as accounts receivable, cash, and other items which either normally convert themselves into cash or are convertible at will within a brief period) and the quick liabilities (those obligations which mature within a period of one year, or corresponding to the period chosen for the assets). Thus for a typical business a ratio of two to one of quick assets to quick liabilities is considered conservative by the majority of bankers, while closer ratios, as one and one-half or one and one-fourth to one may be approved with gilt-edge

assets under certain conditions. The rate of capital turnover (ratio of total annual sales to invested capital) is another unit of measurement. Each of these and other standards of comparison, when worked out for a given set of conditions and applied with an intelligent discrimination, may serve in particular circumstances as a useful guide in establishing standards of judgment and indicating the tendencies of the business. As in all cases, a due proportion must be preserved between the cost of getting the information and the value of its use.

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CHAPTER III

SELLING

THE proprietors of one of the largest men's clothing houses in the United States started as merchants who bought and cut the cloth and farmed it out to contractors who delivered the finished garments to the company's warehouse. Comparatively little attention was paid to manufacturing, and while of late years volume of output has made a place for production men of higher caliber, the point of view of the business has remained primarily mercantile, and its success has been primarily a mercantile and advertising success. It is probably true of most businesses that selling is a matter of large importance, if not of first importance to the directing head of the business. Certainly few important questions of production policy can be settled without a sympathetic understanding of the financial and the selling, as well as the production, points of view.

Problems in Selling.—Selling the product involves several related groups of problems. From the manufacturer's point of view the first problem is that of providing a product that in kind, quality and price satisfies the demands of his market. A second problem is that of selecting and providing the channels by which, mechanically and by persuasive presentation, the product may be made available to the customer. A third problem is that of selling, of awakening a desire for the product, by advertising or personal persuasion, which will lead the customers to buy. A fourth problem is that of coordination, the task of the sales manager who must adjust and keep in harmonious and active operation all the various factors and agencies involved in making the sale.

Channels of Distribution.—The first problem mentioned, that of producing a marketable article, is the task of the production departments. The next question concerns the channels by which the product may reach the customers who demand it. Custom varies largely as to the method used by the manufacturer to dispose of his product. He may sell it direct to the consumer. With large users of production materials such as steel, machine tools, railway rolling stock and supplies, drop forgings, castings, etc., this is common practice, although even here there is a large volume of business done through jobbers, or mill agents. Producers of articles for retail consumption also sometimes attempt mail selling and direct distribution from the factory, in the case of articles where the average unit sale is large, such as heating furnaces or pianos, or in the case of novelties and articles which it is difficult to induce retailers to handle. More commonly, in selling to consumers, the manufacturer sells through a chain of stores or through local agents and canvassers, as in the case of well known manufacturers of shoes, sewing machines, brushes, etc. This type of direct distribution of course gives the manufacturer an excellent control of the market, rendering him secure against the disaster of a sudden arbitrary decision on the part of a single all-important buyer to "drop his line," and making possible direct selling pressure.

But for many articles the average sale made in a manufacturer's store would be too small to make this method profitable. When groceries or other articles are bought, the consumer usually wishes to complete his or her purchase in the one store, involving the carrying of the lines of many diverse manufacturers. The retailer performs an essential function, where the article sold is of small cost, in facilitating selection by the customers and reducing the cost of handling the article. Outside of special lines in which extra selling pressure is effective, the buying habits of the public therefore seem to point to the retail store as an essential link in the distribution chain.

Wholesale Channels of Distribution.—Connection between the retailer and the manufacturer is made in several ways. In the manufacture of cloth it is common for several mills to be represented by one mill agent, who disposes of the whole output of the mill, usually to wholesalers who in turn parcel it out in smaller lots to the retailer. Sale may be made to a wholesaler or jobber, who performs much the same function for the retailer that the latter does for the consumer, that of bringing together for economical distribution a diversity of articles. The expense of selling through a salesman, of shipping by freight, and of doing the clerical work incident to the sale to the retailer of his limited supply of small articles such as pins, grocery items, and many others, points to the wholesaler as a logical channel in such cases. The wholesaler also performs the frequently important function of financing the manufacturer, and of relieving him of the necessity for supervision, and the risk, of numerous small credit transactions. Where the average sale to the retailer is sufficient to carry the expense there are many advantages in direct sale to the retailer by the manufacturer, most commonly through the agency of the travelling salesman. This method where economically practicable has the advantage, as in the case of sale direct to the consumer, of rendering the manufacturer independent of the indifference, incompetence, or capriciousness of the jobber, and of enabling him to carry out a selling campaign in a direct and vigorous way. The choice as to the number of intermediary distributors between manufacturer and consumer is evidently reducible to logical economic principles, of which the most important are the questions as to range of choice either of the same or of different articles necessary to offer the buyers, size of order necessary in order to secure economy of selling expense and freight and delivery costs, and importance of positive market control.

Cooperative Distribution.—In addition to these principal methods of distribution there are a number of others worthy of mention. A frequent practice is for manufacturers of two

or several non-competing lines to cooperate, the salesman of each house selling all lines on a commission basis with or without salary provisions. This enables the various firms to make up combination carload shipments, cuts down the cost of salesman's calls per dollar of business, and where each manufacturer can be relied on to give uniformly fair treatment to the customer, greatly strengthens all the firms with the retailer. It has been used, for example, quite extensively in the furniture trade, where a mattress, bedspring, and bed manufacturer or dining room suite, bedroom suite and upholstered parlor furniture manufacturer get together. It of course calls for more delicate adjustments of interests than independent sale.

Exhibitions.—Sale in a market is also a common method, usually being supplementary to other plans of distribution. Thus at Grand Rapids, Mich., Jamestown, N. Y., Chicago, Ill., and at other points semi-annual "Exhibitions" of furniture are held, which are largely attended by retailers who come to get new ideas and at the same time usually place more or less substantial orders for lines they like. Similar exhibitions have been staged for the display of clothing, of railway equipment, of radio apparatus, of automobiles and of many other lines. Such a display is often a minor feature of trade conventions.

Commission and Auction.—A distributing agency similar in some respects to the jobber is the commission merchant who handles the manufacturer's goods on a stated commission instead of buying them outright for resale. Farm and garden products, also textiles, are examples of classes of goods often sold in this fashion. The auction is another selling plan used in certain trades such as the fur trade, where a great volume of business is done through auctions.

Retail Distribution.—There is a wide variety of methods of distribution in retail selling also. To name only a few familiar agencies there are the specialty store, such as the shoe or music store, or automobile agency, the variety store

(such as the "five and ten cent store"), the convenience store, as the drug store, the chain store, the department store, and the mail order house.

Figure 8 illustrates diagrammatically some of the more important of the channels of sales distribution named in this section.

The manufacturer in his choice of agencies is not limited

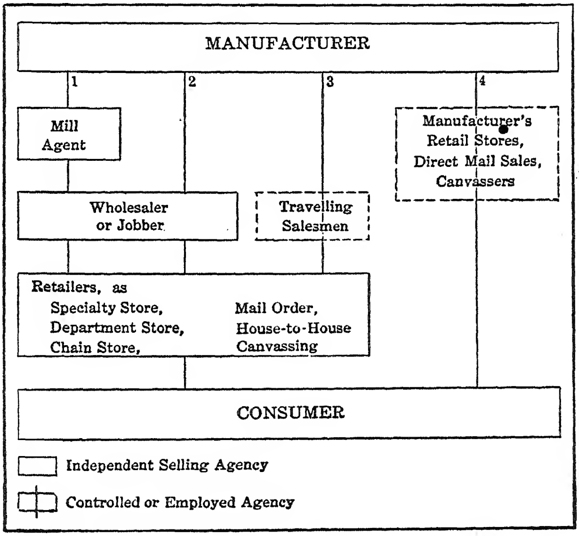

FIG. 8.

CHANNELS OF SALES DISTRIBUTION.

to one type, although usually he confines the distribution in any one territory to one type in order to avoid interference. But he may cover the larger towns by direct salesmen and allow jobbers to handle the remaining territory, or he may similarly handle direct his local territory of a few states and give another manufacturer or jobber an agency for distant territories, or he may combine salesmen's calls for the large customers and "direct by mail" methods for the smaller ones,

with perhaps an annual call in the interest of good feeling. The distribution scheme demands constant attention, changing as conditions change, as the firm expands, as competition develops at one point, as established agencies shift or go out of business, and as demand itself fluctuates with the coming into importance of new towns and industries.

A number of questions of policy arise in connection with the laying out of and contacts with the system of dealer distribution. Shall sales be confined to one class of dealers, as retailers, or shall various classes, such as both jobbers and retailers be included? The small manufacturer may sometimes safely choose the latter plan, but as the number of dealers increases it becomes more difficult to draw the line between dealer and jobber, there is more difficulty in maintaining prices, jobbers may encroach on the manufacturer's customers, and other interferences may develop which force him to choose one or the other alone.

Convenience and Shopping Lines.—Another question of interest in selecting retail distribution points is the distinction made by Parlin between convenience and shopping lines. Small articles, such as soap, collars, or razors, are usually bought at nearby handy stores, the purchaser asking for a particular brand, but not bothering greatly if he cannot get that brand. For this type of article the widest possible distribution, at every corner drug store or neighborhood store, is advisable. On more expensive goods, such as furniture or suits, the customer likes to shop around and compare prices, therefore the larger stores in the more central market districts are the ones most likely to be visited for such goods, and widespread distribution is not essential.

Exclusive Territory.—Another question is that of exclusive territory—giving one dealer a state, a county, a town, or a section of territory exclusively. There is an advantage in the exclusive territory plan in that the one dealer, being assured protection, is more willing to push sales, advertising can be focused on his store and the manufacturer's policies, as to

service, etc., can be better maintained. Continuation of the exclusive rights is usually contingent on the selling of a certain quota of goods periodically. On the other hand, if the one dealer fails to make good or drops the line we are left without adequate representation, so that the present policy tends toward the avoidance of exclusive agencies, especially with large companies which rely on consumer advertising to produce a steady demand for the product.

Making the Sale.—With suitable channels of distribution planned the next step in selling is to convince the dealer and users of the merits of the article and to create a desire for the article which will eventuate into a volume of sales. The process of selling is essentially the same, whether this convincing and creation of desire are done by the printed page or by the personal interview. The basic impulses and motives appealed to are the same, except that in the case of advertising the choice of appeals is made with reference to their effect on a mass audience, while in face-to-face selling the appeal will be directed more specifically toward the known or surmised wants and attitude of each buyer. In each case it is inevitable that a percentage of the effort applied shall be without results. In the case of advertising the percentages of waste is greater than in personal selling, but the cost per approach is also usually much less. Therefore advertising is logically fitted into the selling scheme as a winnowing process which shall sort out the more promising prospects and bring them to our knowledge for the more intensive personal selling appeal, or as a campaign supplementary to and re-enforcing the face-to-face selling appeal.

Creating Desire.—We might divide purchases made by the retail·consumer into three classes: Those things such as food and fuel which are necessities of the habitual conduct of his personal or family life, those things that he buys for the gratification of some specific desire, and those expenditures made as investments, from which future returns are expected to provide for later expenditures of the first two classes. In

both of the first two classes the impulse to buy is not primarily an act of conscious reasoning, it is rather the reaction to habitual or to special desires, impulses, and emotions. A man buys an automobile because he wants it, and his arguments for and against are apt to be what Robinson calls "rationalizing," a more or less unconscious justification and setting up of the color of prudence for the thing he wants to do. He may reason in comparing two makes of cars, yet here also the moment some feature of one or the other car strikes his fancy the decision is made, even though the man still thinks he is weighing advantages coolly.

Among these basic desires may be named the desire for social conformity, approval and distinction, the impulse to imitate others, the appetites and tastes (appealed to for example, in the colorful ads of the "Ham what am"), the desire for good health, the fear of poverty, of accident, the pleasure taken in building and construction, the pleasure in being completely outfitted and ready for any emergency, curiosity, parental love and pleasure in the well-being of one's children. That selling appeal is usually most successful in creating demand which goes most directly home to one or more of these basic desires.

An important effect of this sort of advertising is that it creates a feeling of acquaintanceship and thus of confidence. Where the customer feels himself a competent judge of the merits of an article he is seldom deterred from purchase by lack of familiarity with the brand. But who can analyze a motor oil, or, by inspecting a tailor, can tell whether he will make a suit that will fit? In the vast majority of our purchases we must rely in part or wholly on our confidence in maker or dealer and one of the most effective uses of advertising is in creating this confidence.

Advertising Mediums.—A great variety of vehicles are available for carrying the advertiser's message. To name only a few there are the national magazines such as the *Saturday Evening Post* or the *American*, and the so-called

class magazines such as *System, Gardening,* agricultural journals, or radio magazines. There are the weeklies, the newspapers, the trade and professional journals. There is the class known as out-door advertising, such as billboards, signs, street car advertising, and distribution of posters. There is the class of direct-by-mail advertising, circulars, form letters, or samples, sent to lists of prospects, compiled in various ways or bought from houses specializing in this field. There are the dealer helps, such as folders for counter or mail distribution, assistance in local newspaper advertising, furnishing of cuts, of window and store displays, of demonstrations, signs, etc. Among the latest spectacular advertising stunts was the writing of the name of a well-known tobacco in smoke in the sky by an aeroplane.

Certain criteria are used in selecting from this long list of possible advertising mediums. The manufacturer equipped only to distribute in a small section would be paying for a lot of waste circulation were he to advertise nationally. In addition to knowing the number of people reached by a given magazine or paper, the advertiser will be interested in knowing the class of people reached, their income and interests and tastes, in knowing the mood in which the paper will be read, whether hurried or leisurely, in knowing how long the paper or article will be preserved, in knowing how well it is regarded by those who read it and in knowing whose advertisements will appear in its columns alongside of his own. It is well in the preparation of an advertising campaign to make use of the advice of an experienced advertising agency.

Trade Association Advertising.—Advertising and selling effort designed to create or increase demand, as distinguished from competitive advertising, benefits all producers in the given line. Realizing this, there has been in recent years a widespread movement on the part of Trade Associations, toward cooperative selling efforts paid for by the association and advertising the product in general, new uses for it, and similar topics, rather than any one brand. "Save the surface

and you save all," the paint manufacturer's slogan, "Say it with flowers," of the florist, illustrate slogans first cooperatively advertised and then incorporated into individual advertising. Successful campaigns have been undertaken in the interest of groups of fruit growers, of davenport manufacturers, of yeast manufacturers and of many other interests. They have generally proven very successful when in conformity with the principles of good advertising.

Competitive Advertising.—Why does the customer buy a particular brand, instead of picking out some other among the various competing lines impartially displayed by the dealer? Since this is a question of direction or diversion of desire rather than of its creation, there is more room here for reason and argument, and a simple statement of advantages and reasons for purchase is often effective. Yet even in this field a large portion of the total result is achieved by the use of suggestion rather than reason. Suggestion is shorter, can be conveyed by pictures where printed words would be too long or too unattractive to catch the attention, and has the advantage of not arousing opposing arguments in the customer's mind. The article is pictured in association with well dressed people, or of some symbolic object such as the Rock of Gibraltar, or a simple assertion is made of its merit. Gradually an impression is built up, by assertion, by association, by suggestion, by repetition, in the customer's mind.

Selling the Dealer.—Most manufacturers whose product is sold to the final consumer sell through an intermediary, the retail dealer, and it is to the latter that the direct sale is made. A separate analysis is necessary to reveal the appeal which will be effective with the dealer. First he must be convinced, as the customer would be convinced, of the merits of the article, for this is one of the tests he applies in buying. Then come special arguments to convince him of the ease with which the article can be sold, of the profits, the rapid turnover, the increase of prestige and sales which will come from handling the goods.

It is not hard to get the dealer to try a sample lot of the goods in most cases, for the average retail store buyer is alert to new lines and likes to try them out and look them over. The real task comes in keeping the goods moving across the dealer's counters into the hands of the consumer. The dealer is not entirely a passive agent. If he has been thoroughly convinced of the merits of the article or of the desirability of pushing its sale from the standpoint of profit, he will put a certain amount of pressure behind the sale of the line. But usually there are two or three competing articles on his shelves beside this manufacturer's particular line, and profits being equal, or even if they are not, the dealer takes the line of least resistance in selling. Hence the interest of the manufacturer in consumer selling, for if the goods are to be moved, the manufacturer must provide much of the force which will move them. The primary method, of course, is to put the value into the goods so that buyers will like them, will come again and tell their friends to come. Advertising comes in as a sort of megaphone, amplifying and hastening the carrying of the message. And this advertising, as mentioned, is planned to synchronize with the displays and efforts which the dealer is assisted to make in his locality.

The element of personal friendship, respect and confidence enters into dealer sales as in all business transactions. Jones buys our goods not only because they are easy to sell but because Jones feels that we have a personal interest in his success and take pains to fill his orders carefully. Perhaps we have helped Jones out by credit accommodations at a critical time. He has found that he can depend on us to ship promptly, and to save him petty annoyances such as disputes over freight bills or shortages and errors in description.

Creating Good Will.—Paid advertising and high-pressure selling are not the only means of creating a demand and a good will for the article, although they seem to have been a factor in the upbuilding of most large businesses, particularly those whose product is sold to the consumer. The uniformity

of quality secured by careful inspection, promptness and reliability of service, courtesy, established policies which the customer comes to feel he may depend on, these are part of the bedrock of most successes.

Concentration.—Generally speaking, except in special cases such as technical articles appealing only to some special class of widely scattered users, it is best to secure a sufficient concentration of sales effort in one locality to produce profitable results before entering new territory. For example, in building up a business, better results would be likely to be secured if one state at a time were taken and thoroughly covered by salesman's calls and local mail and newspaper advertising, than if a wide-flung campaign, producing a less concentrated effort over a larger territory, were attempted. As the Chicago *Tribune* once put it, there is a critical speed for selling campaigns, as for aeroplanes. An aeroplane might run for miles at thirty five miles per hour, and never launch itself. It is only when the speed increases to forty miles or more that it will rise.

Sales Management.—The sales manager is the man on whom rests directly the task of crystallizing all of these general principles of selling into result-bringing action. To do this involves, in the first place, coordination of the activities of the other departments so that quality, scheduling, accuracy of filling orders and of clerical work may be depended upon. It involves, in the second place, planning the campaign of argument, suggestion and acquaintance by which the initial sale is made, and selecting and directing the salesmen who will carry out the campaign. And it involves keeping the customer enthusiastically sold on the line, from that point on.

For this second part of his work, the sales manager has recourse to two types of approach. One of these is advertising and correspondence. For some situations, it is possible to sell exclusively by mail, and at a cost of few cents per contact with the customer instead of several dollars for a salesman's call.

But while mail selling is cheaper per unit contact, it is in general less effective. The salesman is on the ground, he can intelligently particularize his arguments to fit the exact local need, he supplies the personal element so useful in the contact, and he brings the buyer more effectively and definitely to the point of decision. He can also act as a scout and gatherer of information for the house in several important directions. He can form a personal estimate of the desirability of the prospect from credit and other standpoints, which, while not final, gives a good check-up on other reports. And he is on the ground to report local trade conditions and prospects, activity of competition, price charges, new prospects, and other useful facts which come in more slowly, if at all, through other channels.

Selection of Salesmen.—The management of salesmen involves first of all the selection and training of the right man. Men are secured by promotion from the company's ranks or local selection of promising men, by applications from salesmen with previous experience, by advertising, and similar means. The process of training varies greatly. Frequently the prospective salesman is given several months' training in the factory, so that he will be able to give intelligent information and service to the customer in his selection and use of the product. He may also attend classes in which he takes part in demonstration sales, and is required to answer lists of hypothetical objections to the product. He may next be sent out on the road in the company of an older salesman or a teacher, first watching the latter make actual sales and analyzing the sale with the latter after it is made, then doing the selling himself, and receiving the benefit of the teacher's suggestions and criticism.

Scheduling.—In the second place, sales management involves the direction of the salesman, his scheduling and control in much the same fashion, fundamentally, that the activities of production are scheduled and controlled. The territory will first be divided, with a salesman for each local

division. Within this division it is expected that the salesman, backed by the house, will build up a trade, taking over and holding established customers and adding new ones. The plan of payment of the salesman is usually so arranged by commissions or salary or otherwise that the man's own personal success and advancement are a reflection of his efforts in his territory. The territory will be arranged with reference to known standards of time per call, for transportation, etc., so as to assure approximately the best concentration of sales effort for results if the salesman applies himself.

Once the territory is assigned, the day-to-day activities of the salesman will be controlled to a greater or less degree by the sales manager. He will be given a list of stops to be made, furnished with information as to credit, lines handled, etc., for his prospective customers, supplied with information as to dates of delivery and stocks on hand, and in other ways his activities will be planned and supervised.

Sometimes the schedule of the salesmen for a territory is visualized to the manager by what is called the "map and tack system." Location of customers will be shown on a large map of the territory by different colored pins, a red pin indicating perhaps a certain type of customer, as a wholesaler, a green pin, a retailer, and so forth. On this map the territory of each salesman will also be indicated, and if desired, his movements may be laid out on this map, numbered tacks indicating the dates at which he is to visit certain towns on this route.

Figure 9 illustrates the record used by one sales manager for keeping the history of each customer from the sales standpoint.

Sales management also includes the study of the best routing and means of travel, the decision as to whether to equip a salesman with an automobile and have him travel in this way, or to have him use railroad or electric trains. It includes, in connection with the general executive and financial control discussed in Chapter II, the setting of quotas and standards of output and the devising of suitable plans and

standards of compensation. It includes also the auditing and control of the salesman's travelling expenses.

Support by the House.—Finally, the effective management of salesmen must include the support of the salesmen by the house. "Leads" and information as to prospective customers must be promptly furnished him, as they are secured from advertising, by direct inquiry, or from other salesmen. He must be kept informed of prices, supplied with fresh samples, told of advertising plans under way and supplied with

Prospect Listed	ASSIGNED		CUSTOMERS DATA CARD
	Salesman	Date	Name Address Buyer Business Phone
______19__ First Sale ______19__			

SALES	19	19	19	19	19	19	CREDIT
January February March April May June July August September October November December							Rating Terms Notes ADVERTISING Mailing List 19__ Special Adv.
TOTAL							
Notes							

FIG. 9.

SALES DATA CARD.

copy, furnished with late credit information as to new and old customers, and above all, constantly made to feel the support of the house. And in the face of the arguments and criticisms and indifference of the buyers he meets every day, he must be kept enthusiastically "sold" on his own goods. Many concerns go farther, and keep the salesman informed of production conditions, so that he may directly assist in directing sales away from overcrowded departments to slow moving lines. One company has followed the practice of sending out monthly to its salesmen, photographs of a schedule board which shows work ahead of each machine.

The salesman on the road meets constant opposition, arguments, discouragements, appeals or demands for special concessions in the way of price, terms, credits, and other matters. If he is too long away from the house, or its representatives, he drifts out of touch with the house. He may become discouraged, he may not be informed fully of new lines or late developments, he may come to take the customer's point of view too much, to make undue concessions or to develop a critical attitude.

To keep the men lined up and "sold" on the house and the goods, many companies make arrangements which regularly require the salesmen to report at headquarters. Here a sales convention or a talk with the manager and a trip through the plant puts the man in touch with latest developments and starts him out with a fresh supply of that enthusiasm on which such heavy demands are made by the day's work.

Sales versus Production.—A conflict of interests frequently arises between the sales and manufacturing department. The sales department in its desire to serve its customers' wishes, tends constantly to make unnecessary variations from standard designs, entailing additional expense, and to make delivery promises which either cannot be met at all or involve a costly interruption of established schedules, the breaking down of set-ups to run through small lots, etc. Frequently these things are the necessary price paid for giving the customer the service he needs. The best compromise between manufacturing and sales efficiency will be made when both departments are kept informed, by mutual conference and by schedules and similar bulletins, of the needs and problems of the other, and when a general executive who is aware of the problems of both fields lays down the policies which are to guide action and makes decisions in the specially knotty cases. Profitable fields, for example, exist either in the standard product or the made-to-order fields. But one or the other must usually be chosen, since if an attempt is made to straddle both fields in one shop, neither the low cost advantage

of the standardized field, nor the service advantage of the other, can be fully attained.

The manufacturing end stands as an essential foil and support to the efforts of the sales force. It must be kept in tune, so that rigid inspection may back up the promises of quality made by the salesmen, and so that prompt delivery may support his arguments of good service.

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CHAPTER IV

TYPES OF PRODUCTION CONTROL

In order to give a bird's-eye view of the steps in production it will be well to follow a typical customer's order through the factory and see the steps taken in filling it. The illustration will be taken from a jobbing or special order industry, since all the steps are taken here with are taken in the shorter and modified procedure of other types.

Steps in Filling the Customer's Order,—Special Order

Making the Sale.—Sale of a special product, say a special conveying machine built to customer's order, involves first, location of the prospect, through advertising, trade journal news, inquiry received, or other means. After ascertaining the credit standing of the prospect the salesman calls, and if he succeeds in interesting the prospect, secures facts as to the required installation, which he sends in to the home office. Here preliminary rough plans and sketches are worked out and an estimate of cost made. If this estimate is accepted by the customer an order is sent in, and received by the general office.

Customer's Order is now finally approved for credit, is checked for accuracy of description, prices, and extension, given an order number which will in the future serve as its identification throughout the shop, and usually copied onto an order form.

Engineering.—It will now be turned over to the engineering department, which will develop the preliminary sketches into a detailed *bill of materials* with supporting drawings, in which each part is accurately specified as to dimensions, material, finish, etc.

SHOP ORDER

.... Department, please	Manufacturing Order No. ....
deliver items as follows to	Date Ordered .... 19 ......
.... department.	Date wanted .... 19 ......
Description	Date delivered .... 19 ......
....	No. of pieces ....
Remarks	Symbol ....
....	Pattern No. ....
	Drawing No. ....
Signed	....

FIG. 10.

SHOP OR MANUFACTURING ORDER.

BILL OF MATERIALS

Standard Bill of Materials Pattern number ....

Standard Name ....

Size and description .... Date .... 19 ......

....

Material required to make ...... article ......

Item No.	*Quantity or Weight*	*Secured from Dep't. No.*	*Description*	*Standard Pattern No.*	

FIG. 11.

BILL OF MATERIALS.

Stock Check.—The bill of materials will next clear through the stock record department where it will be ascertained for each item whether it is in stock. If it is, in many cases enough stock will be reserved or apportioned on the records to fill the specific order. If not on hand, an order will be issued for its purchase.

Routing.—The bill of materials, checked for items in stock, and the blue prints will now go to the manufacturing department, where shop orders will be issued for the making of the parts which are special or not in stock, and for assembly. In some cases routing will involve preparation of specific instructions for each operation on each part to be made. The forms and methods used in routing are specifically discussed in Chapter V. (See Figure 21.)

Scheduling.—The detailed manufacturing orders, which so far specify only method of manufacture and machines to be used, must now be given a specific date of performance, this date being embodied in a schedule or operating program.

Dispatching.—This step is a relatively simple one, the order being given to the proper man for performance, on the date scheduled.

Operation.—Including assembly and inspection, is the next process.

A Progress Record.—This record is kept to enable easy location of the order while in production. (See Figures 21, 51, and 52 for typical progress records.)

Follow-up.—Follow-up of the order proceeds parallel with operation, making sure that each operation is completed on time.

Shipping and Billing.—The completed, inspected product is delivered to the shipping department as finished. This department will have a list of the orders to be shipped, or preferably, duplicate copies of the shop orders and bills of materials. The order will be packed and counted and a packing list showing each item included will be enclosed in the package. This packing list will be compared with the shipping

copy of the shop order and any changes or omissions noted. This shipping copy of the order will then be turned over to the billing department, which will prepare the customer's invoice, of which one or more copies will be mailed to the customer and one or more copies retained for office use. From the office record copy, the amount of the invoice will be posted to the customer's account by the bookkeeping department in its books of Accounts Receivable.

The shipping department will submit the product to a final inspection while packing. It will make out the usual triplicate bills of lading if the shipment is to go by freight, or an express receipt or driver's receipt for express shipments or city deliveries respectively.

Upon payment by the customer, his account will be credited and the cycle of filling the order is complete.

Costs.—At the commencement of work on the order a special cost sheet copy of the order is delivered to the cost department. As any expenditure is made on the order, by the engineering department for time in preparing plans, or by production through the use of materials or labor time, a record of the expenditure is made by means of requisition or time card which is identified by the order number previously mentioned. This record of expenditure is sent to the cost department and posted to the job cost sheet. When the job is complete these costs are totaled, the proportion of indirect expense chargeable to the order is added, and the total cost obtained. A typical time card and cost sheet are illustrated in Figures 54 and 59.

This brief outline of the principal steps in filling an order in the special order industry is graphicallv shown in Figure 12.

Classification of Industries

The Special Order Industry.—The special order industry, referred to above, is one in which a major part of the work on every order, including the designing of the product or the

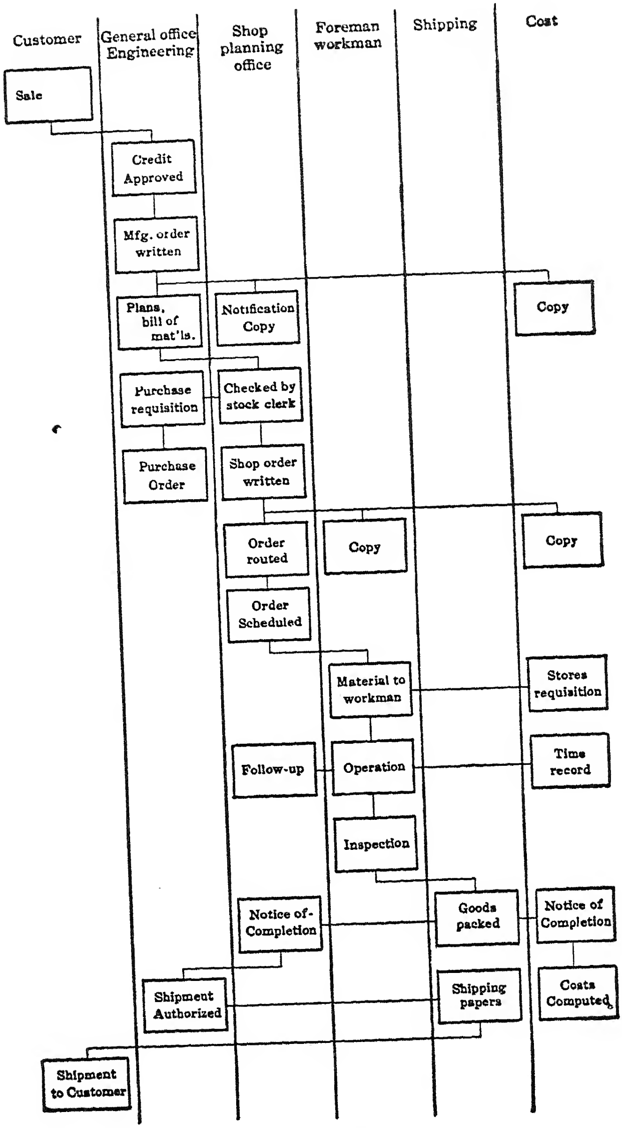


FIG. 12.

PROCEDURE DIAGRAM, SPECIAL ORDER INDUSTRY.

adaptation of a standard design, is performed separately for each order. The work of a job printer is of this type. The making of special machinery, bridge building and structural shops, and other common industries also fall in this classification. It is characteristic of shops of this type that equipment is chosen with a view to general-purpose utility rather than the last fraction of efficiency for any one operation, and, because demands on any one machine are variable, it is apt to be over-equipped as compared with a straight repetitive industry. A larger percentage of its workmen must be all-around men, capable of relatively more independent work than is the case in the repetitive industry where a man is called on only for one routine operation. The special order industry carries little or no finished stock or finished parts, although it must carry raw materials in stock. In many industries, such as job printing, even the stock of raw materials is usually limited, paper being bought for many jobs after the order is received. In the special order industry also, since each job is apt to require a different sequence of processes, scheduling and control of movement of material through the shop must usually be comparatively detailed, and more elaborate than where all work automatically moves through a single established sequence of operations.

A variation of the special order type is found in what may be called the lot repetitive type of industry. As demanded increases for some of the many patterns which the company has previously made up to order only, it becomes profitable to put work through in larger lots, carrying the unsold portion of the lot in stock to fill future orders, and replenishing this stock by putting through another manufacturing order before the earlier lot is completely exhausted. When the industry has become predominantly of this type, demands on the design function of laying out the product, and routing it or laying out the sequence of manufacturing operations, will become only occasional, since most patterns will have been made before and the drawings, bills of material and

route sheets will be available for handling the additional lots. Machinery will still in the main be general purpose, since it is called on to handle a variety of operations. Workmen also, will need to know several operations, although no longer called on for an absolutely new job with every order. Stocks of materials and finished parts or product will usually be heavier than in either the special order or the flow repetitive type, since so many patterns must be carried and available for filling orders. Scheduling control must still be detailed, but the number of orders and items handled will be fewer, since the average lot is larger. Examples of this type are found in many manufacturers of variety goods such as door hardware, furniture, or tools. This type is a very common one.

When the demand for one pattern becomes sufficiently great to justify putting through a lot every day, we have the theoretically limiting case in which the lot repetitive industry merges into the **flow repetitive type.** Ford's automobile industry is the best-known example of this type. Instead of being manufactured intermittently the product now moves through the factory in a steady stream, whose volume may increase or diminish according to demand, but is seldom totally interrupted. Instead of using general-purpose machinery, arranged for the best average economy in handling varied orders, we now have the entire factory specialized into one closely articulated unit, each of whose machines performs one special operation and is arranged to permit the most direct flow of materials to completion. In the other two types, since the machine capacity is balanced only for an average mixture of orders, one process may be quickly completed, and the lot may wait for days or even weeks to take its turn for the next process at a machine group which happens to be temporarily overloaded. In the flow repetitive type, as long as no break-down occurs, the capacity of each machine is adjusted to pass forward daily its particular quota of operations to produce the daily output. Machines are

narrowly specialized, so are most of the men, and a lower grade of machine tenders, with a few skilled mechanics to keep things in order, may be employed. Material moves faster, little is normally carried in stock, and the inventory investment is therefore usually lower than in the lot repetitive type.

The basic difference in the method of control in the three cases may be brought out by comparison with the various methods possible for controlling the water supply used, for example, on a country estate. One of the methods (Figure 13) would be to start the pump *"A"* whenever water was needed, shutting it off when through. This corresponds to the special

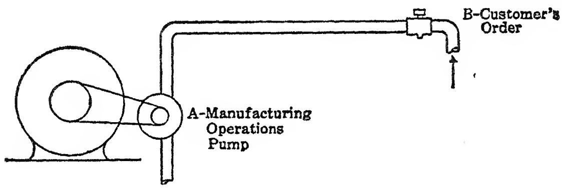


FIG. 13.

STOCK CONTROL IN SPECIAL ORDER FACTORY.

order plan. A second method would be to carry in the reservoir *"C"* (Figure 14) a supply of water sufficient for normal needs, the supply being automatically replenished by the operation of the float control *"D,"* operating when a low level was reached, and until the tank was filled to the high level. The actual mechanism of this control in the variety repetitive industry is the system of maximum and minimum stock limits, a production order being automatically placed when the minimum is reached, sufficient to bring stock up to maximum. If in Figure 14 we consider the pump as operating continuously, small fluctuations being taken care of by the reserve capacity of the tank, and the stock limit control operating only when the adjustment of the speed of the pump by per-

sonal supervision had been overlooked, we will have a system closely analogous to that found in the repetitive industry.

Intermediate Types.—Many variations, mixtures, and intermediate forms of these three types will be found, and all three may be found operating side by side, one group of machines being on continuous production, another group on lot repetitive or special order work. An interesting combination of characteristics of two types is furnished by the made-to-measure men's tailoring industry. The process of making a coat is substantially the same whether it is of one pattern or another. Here and there a pocket is changed or an extra pressing operation added, but as a whole all coats pass first through the cutting operations, are then assembled with the

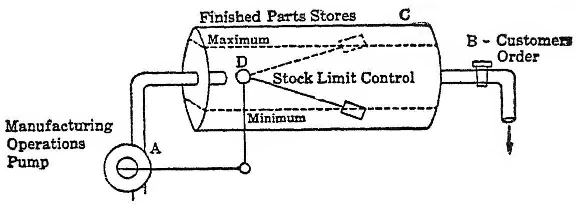


FIG. 14.

STOCK CONTROL IN LOT REPETITIVE FACTORY.

cut linings and findings, and are then sent to the tailor shops, where the various operations of sewing, pressing, buttonholing, etc., and inspection, are performed in a nearly standardized sequence. Therefore as a whole the machinery and processes are arranged as in the flow type. Scheduling of particular operations is not necessary, since one follows another in almost automatic sequence. However, along with this almost completely standardized flow of the product there is the need for detailed special instructions for each coat or small lot of coats. One lot may be of sport model and must have patch pockets or extra buttons or distinctive lapels, the next, a standard sack suit. The need therefore exists

for detailed method instructions or routing, and a complete instruction card specifying how each of the varying operations is to be performed, style of button, color of threads, style of seam, etc., is made out and travels with the garment to completion.

Another interesting intermediate case is furnished by the automobile manufacturing company whose output is great enough to put part of the production on a flow basis, while part is intermittent. Imagine, to illustrate this case, a company which is assembling its cars by the progressive or flow plan, the developing car being moved by a slow conveyor past successive stages or positions, at each stage a part being added or an operation performed, until at the last stage the finished car is supplied with gasoline and driven out to the test track. Some of the larger units parts may also be made in sufficient quantity to employ the progressive plan of manufacture. But on many of the smaller parts, gears perhaps for example, there will not be enough production to keep a machine or producing unit busy. Only one model of car, we will assume, is being produced, so the total volume of parts will remain relatively constant. For the production of these intermittently produced parts we would then probably find that a lot system was employed, the machine turning out a lot of a thousand of one type of gear, which are put in stock and used as needed, then say two thousand of another type. This program will evidently be periodically repeated, and scheduling and general control may well approximate the flow repetitive type, yet the arrangement has many features of the lot repetitive type. Other combinations and examples will suggest themselves to the reader but are hardly necessary here to bring out the distinctive characteristics of each type.

It is of interest to note that each of the basic functions of design, supply, control and operation, and in many cases each subdivision of the function, may be examined separately and the industry classified as being special as to design, while per-

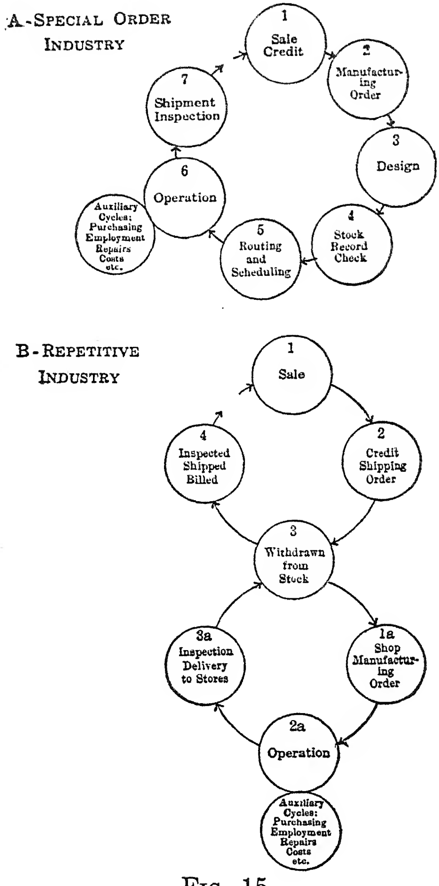


FIG. 15.

COMPARISON OF OPERATING CYCLES IN SPECIAL ORDER AND REPETITIVE INDUSTRIES.

haps of flow type as to arrangement of machinery or scheduling.

In the special order industry the cycle of filling the customer's order included the whole of the direct operating processes of the factory. In the lot repetitive industry the

process of production is broken into two cycles, shown in Figure 15.

Mapping the Course of the Order—Graphic Methods.— One of the useful means of study of the factory organization is the preparation of standard-practice instructions covering procedure in filling orders or other routine processes. The preparation of instructions is an excellent method of analysis because it compels the putting down in writing or diagram of a complete outline of the procedure, and indicates very clearly, loose ends and bad joints in the system. The instructions also make a good record of the standard practice adopted, a record useful in checking up at intervals for slippage, and in instructing new men. Such a record cannot take the place of verbal explanations and of example, however.

The instructions may be put in several forms. One of these is the manual of instructions for procedure, of which a typical illustration is shown in Figure 16. Another plan is the use of one of the various forms of procedure diagrams, illustrated in Figures 12 and 17, which show each step in the routine, very clearly in relation to the succeeding and preceding steps.

Figure 16 is a typical example of this form of instruction. It is often desirable to supplement such an instruction by some form of diagram or chart, mapping graphically the steps taken in each routine. Such charts are especially useful in studying an organization. The procedure described in the standard instruction given above is put in the form of a chart in Figure 17.

This diagram has the virtue of simplicity and of making clear the chronological order of the clerical steps. Another form is found in the plan of "geographical" presentation. In this type the course of the order through the various departments, important files, etc., is shown in a diagram either drawn approximately to scale or showing roughly the relation of the departments to each other. Then the path of the

PROCEDURE COVERING RETURNING AND REORDERING DEFECTIVE PRODUCTION MATERIALS

Subject:

The departments enumerated below are responsible for returning and reordering defective materials specified below, being governed by circumstances as specified.

PURCHASING DEPARTMENT. All purchased commercial articles, rejected before being placed in production.

MATERIALS DEPARTMENT. Production materials of any nature, rejected at our plants while in production.

THE PROCEDURE COVERING THE ABOVE CASES IS AS FOLLOWS:

(1) Upon receipt of notice from the salvage department of rejection of material not yet in production, the PURCHASING DEPARTMENT will immediately issue a Purchase Order in the usual manner, reordering what was rejected, but specifically stamping each copy of the Purchase Order "Replacement Order," and quoting the former Purchase Order number. Judgment must be exercised in reordering small quantities of returned defective material, since it may be desirable in some cases to accumulate such quantities until a Purchase Order covering large quantities may be issued. Return of material of this nature to the vendor will be authorized by the Purchasing Department.

(2) The MATERIALS DEPARTMENT will obtain data as to rejection on materials in work in the plant, from the "Rejection Report," form 307. Judgment must be exercised by this department as to reordering materials rejected, in desirable quantities and obtaining them within the time required. Due reference must be made to the stock ledgers in respect to quantities on hand, required, ordered, received, etc., and care must be used to ascertain whether the established percentage of allowance for scrap is sufficient to cover these rejections without reordering.

When a desirable quantity of Rejections to be reordered has accumulated, the Materials Department will place on the Purchasing Department a "Requisition to Purchase," (form 117), marking this requisition "Replacement of Rejected Material." The Purchasing Department will then reorder as described in (1).

Copies to   Signed .... Manager.

Mr. ....

Mr. ....

FIG. 16.

FORM OF PROCEDURE MANUAL.

order through the various departments is shown by a line, with arrow heads showing its direction from one department to another. Various forms may be indicated by different colored lines, the steps may be numbered, and other devices used to produce a clear picture.

Figure 12 illustrates a modification of the plan of presentation showing Figure 17, which has the virtue of especial clearness and compactness.

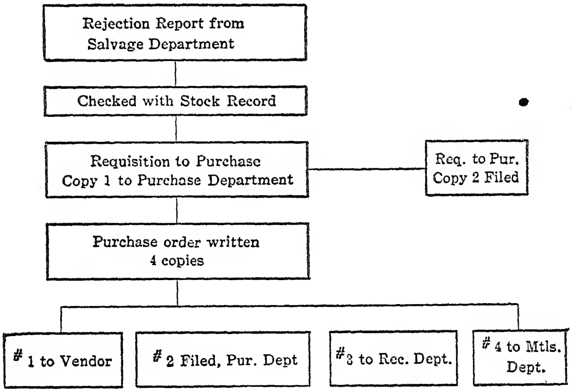


FIG. 17.

ROUTINE FOR REORDERING DEFECTIVE MATERIAL BY MATERIALS DEPARTMENT.

A Typical Case: Steps Taken in Filling the Customer's Order (Men's Wholesale Clothing Business).—In the clothing business to be described, the general line to be manufactured is estimated in advance and woolens are purchased according to the sale estimated for the various patterns. Detailed orders, however, are secured by the salesman from a showing of samples to the customer, and these orders are taken for specific sizes, models and patterns of material. Practically all work of the factory is done under these orders.

In the manufacture of men's clothing, the general sequence of operations is approximately standard, the first major

operation being the preparation, shrinking, steaming, etc., of the cloth; the second, the cutting of the cloth; and parallel with this the cutting and assembling of findings, buttons, linings, etc. The third operation is the tailoring of the garments, which includes the operations of assembling, sewing, pressing, inspection, etc., which are nearly standard for all garments. The general type of business may then be said to be of a flow type, modified by the necessity for accompanying each lot of goods with special instructions.

Taking the order as it is received from the salesman by the general office, the first general step is the examination of the order, and the putting of it into completed form for the guidance of the shop. The amount of the order is first totaled on the comptometer as a check on the salesman's figures. The original order sent in by the salesman is then sent to the credit department and credit is approved before further work is done. It is given a registry number for identity, which follows the order and all lots made under it through the house. A statistical record is then made for use on the Hollerith tabulating machine, showing the amount of the sale, suit pattern, salesman, territory in which sold, and the goods pattern, and daily totals are taken from these records, of the sales by suit pattern, by goods pattern, by salesman, and by territory. If the statistics show that any particular pattern of goods appears to be approaching exhaustion, additional goods are ordered from the woolen mills. These statistics are also a guide in the ordering of material for the coming season, and the other compilations are used in checking the ability of salesman, the popularity of models, and the probable sales by sections of the country. Following this statistical analysis, a check is made of the original salesman's order for errors in price or description; and any special directions identifying the model, indicating the store room section number from which the material is to be taken, etc., are added.

The second main step in filling the order is then taken by

the analysis of the original sales order into a group of suit orders, one for each model, kind and size of suit ordered. Each of these orders is written in triplicate. The first copy is filed in the order department by the goods pattern number, the second copy goes to the filing department, where it remains on file until the completed lots of suits is received for shipment. The third copy goes to the stock floor for check against completed goods, and is then held as a back order record in case the order is not complete.

The file of suit orders by goods pattern number, into which the original order was put, is gone over daily. The orders for suits of similar pattern and goods, to be delivered at about the same time, are taken out and assembled into lots. Thus, if a customer had ordered one suit of young men's model, pattern #216, for delivery January 15th, and another customer had ordered three of the same suit, for delivery on the same or an adjacent date, these four and any other orders for same model would be grouped together in the same lot. An attempt is made to include at least eight or ten suits in a lot.

The lot now starts through the shop as a new suit or shop order. The order is written in three parts. Of these the first is the cutter's card which specifies the number of suits, pattern numbers, and any detail information concerning the order (thus, special flap pockets, etc., may be specified). The second part of the order is the lining cutter's card, and this specifies in full detail the material required for the linings. The forms for these shop order cards are standardized so that it is only necessary to insert pattern numbers, etc., where variations occur. The third part is called the tailor's tillet, and specifies the findings or trimmings required (thus, buttons, thread, etc.). The cutter's card is sent to the stock room. The goods required are taken out and sent to the cutter. The whole bolt of cloth is usually sent and is charged to the cutter on the stock record card until the unused portion of it is returned. The material is now sent with the card to

the cutter, where it is cut, inspected, and tied into a bundle to which the cutter's card is attached. It is now sent to a sorting bin. A similar process is pursued for the lining cutter's card. The linings are gotten out of the stock room and cut, are bundled and sent to the sorting bin. The findings are gotten out in the same way, the tailor's tillet being used as the identifying tag at this point. Piece work payment slips are also put with the order at this point. Coupons are detached from these slips as the various operations are completed, and are retained by the employees as their record of earnings. A list is prepared each day of the orders sent to the shop, one copy being given to the superintendent of the shop receiving the goods.

The tailoring is done in a number of shops scattered throughout the city. Each shop receives its material cut and assembled ready for tailoring, and returns within a specified time the completed suits. As the superintendent, or foreman, receives a consignment of goods ready for tailoring, he checks the bundles with the list of orders, and the completed suits are again checked as they are returned. The goods now go through the various shop operations, ending up with pressing and inspection, and are returned to the general office. Here they are sorted by orders, the coats, vests and trousers being separated, and are sent to the finished stock floor, checked with the back order copy of the suit order and held pending authorization to ship. The back order copy, after being checked, is sent to the credit department as a notification that the order is ready to ship, and must be again approved by this department before the goods are sent out. On the return of the back order copy to the finished stock floor, the goods are forwarded to the shipping department. While all this work was being done in the shop, the billing department, which received a copy of the original suit order, has prepared a contents slip, of which two copies are sent to the packing department and filed there. On receipt of the goods from the stock floor by the packing department, a check is made with

this contents slip, a copy of the slip is packed with the goods and the goods are shipped to the customer. The other copy is returned to the billing department and checked with the original suit order, and a bill is rendered to the customer. This completes the steps directly involved in the filing of the customer's order.

No mention has been made of the accounting system by which the time and piece rate earnings of the various cutters, tailors, etc., as shown by the completed orders and by piece rate coupons turned in, are assembled into costs. From the direct labor and material costs, and the shop administrative overhead, a shop cost is obtained for the garments. To this is added the administrative and selling overhead, giving the final cost, which is reported in a monthly financial report.

REFERENCE

Babcock, G. D., *Taylor System in Franklin Management.*

CHAPTER V

MANUFACTURING DESIGN

THE design function, as we find it in production, covers a wide variety of forms of organization and of problems of technique. The chemist devising new formulæ, the engineer working out the computations for a new machine or structure, the inventor, the artist producing advertising or new clothing styles, each of these men, working in a widely different field, is performing the design function for some industry.

Design Problems.—Design may be of two types. Usually an industry has certain basic principles or standards, or a limited number of models, which are used in varying combinations to fill a wide range of customers' needs. Thus a conveyor building business was developed from the original idea of a certain type of link belt to which buckets were attached. Various lengths and types of conveyor or bucket were combined with this basic type and other modifications were made as needed to make the apparatus suit the customer's needs. The development of such basic ideas, of original models or styles, is a first type of design, quite commonly separated from design of the second type, that of adapting and varying these basic ideas to fit the specific case. Often the work of origination is only occasional and the firm may continue for long periods to make a single model with little change. Most large businesses, however, in a desire to keep abreast of developments have some sort of an experimental department in which are incubated the new developments which it is hoped will bear fruit in increased sales or greater economy and effectiveness.

The General Electric Company, the Eastman Kodak Com-

pany and many others, maintain corps of scientists, inventors and investigators who explore not only the possibilities of immediate development of the product, but also reach far into the future, conducting purely theoretical investigations into the nature of electrical waves, or chemical action of light, whose direct application is not expected for years to come. Attached to such a large experimental department would be found completely equipped testing and experimental laboratories (which may serve other purposes also, such as testing materials) and also good libraries and facilities for abstracting and using the published results of the research of others and for following applications for patents and securing desirable patents where possible. Suggestion systems, for encouraging and giving prizes for ideas which may occur to workmen or other employees, are also used to gather the chance ideas and the many suggestions for detailed modifications of method which may arise from this source.

Suggestion Systems.—A typical suggestion system would embody features corresponding to the following: A committee on suggestions is appointed, usually including the manager or some other executive officer, together with representatives from the engineering, planning and perhaps sales departments. This committee meets monthly to pass on suggestions. Suggestion boxes are placed at the time clocks or in other convenient places and blank forms may be supplied. Some firms provide that the workman may put his suggestion in under a number, to be identified by a check envelope after approval, so that there will be no possibility of favoritism or antagonism. Suggestions may be entered under various classes, such as: (1) product and process methods, (2) system and organization, (3) criticisms and suggestions as to personnel methods, (4) safety. For each accepted suggestion one dollar or more is paid. A letter acknowledging receipt of the suggestion and expressing appreciation of the interest shown is sent to everyone who turns in a suggestion. Every month, prizes are awarded for the best, second and third best

suggestion in each class, the right being reserved not to award any prize for suggestions not up to a certain standard. Employees are also encouraged to make contracts with the company for development of patentable ideas, by which they receive royalties or a lump sum for their interest in the patent. This arrangement would of course not be made with men hired to devote their time to the development of new ideas on a salary basis.

Every means is sedulously cultivated which will bring new ideas into the business. Outside consultants may be hired so as to get the benefit of a fresh slant at the problem, proceedings of learned societies, trade papers, exhibitions, and similar means are used. In the smaller plant the work of origination may be one of various duties of some executive or an outside consultant may be hired from time to time.

Routine Design.—The engineering department furnishes a typical example of the provision made for the second type of design, the modification of basic patterns to meet routine requirements, although it may serve often for development work also. As mentioned in Chapter II the first part of this modification to suit customer needs is often performed by the salesman, often a man of engineering training, who, being on the ground, secures dimensions and submits preliminary sketches showing what the customer needs. Assuming that the job is of some complexity these sketches will be passed over to an experienced engineer or designer who will decide the method of construction, in contact with the customer or the company's special representative and will oversee and approve the development of detailed plans. Sections of the job may be given to assistants who work out the details to fit general plans, in turn assisted by tracers, letterers, and others to whom much of the purely detailed work can be given. Specifications and a bill of materials will be worked out from these plans.

This is the first step in design. It tells precisely *what* shall be made. The next step is to tell *how* it shall be made.

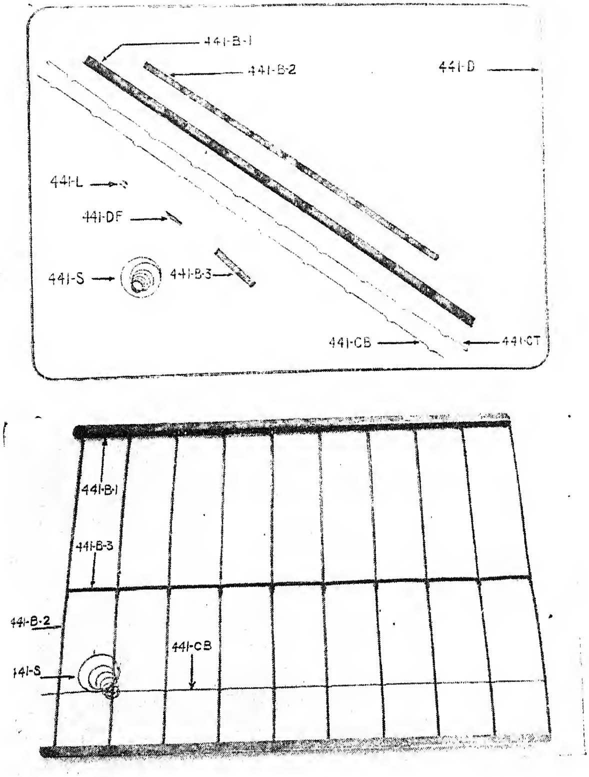


Fig. 18.

UNIT PARTS AND ASSEMBLED BASE OF MODEL 441.

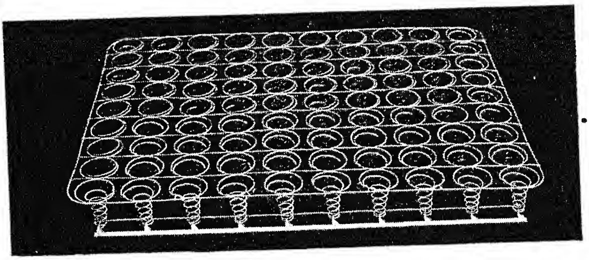


Fig. 19.

COMPLETED BEDSPRING MODEL 441.

Operation Analysis or Routing.—Telling how the article is to be made involves in the first place an analysis of the product, showing the various operations to be performed in its making. If it is an assembled article there will be two stages in this analysis, first the listing of the various unit parts and their combinations, into sub-assemblies and final assemblies, second the listing in order of each operation on a unit part or assembled group. This process of analysis may be conveniently illustrated by a concrete example, the assembly of an ordinary coil bedspring such as one of those built in the writer's factory. Bedspring model "441" consists of a steel base or slat and a spring wire superstructure. The base is assembled first, and consists of two angle iron side rails which run the length of the bed, connected by cross slats running across the bed. Holes are punched at regular intervals in these cross slats and "crimp wires" are run through them parallel with the side rails, forming with the slats a sort of network of intersecting slats and wires.

The spring superstructure is now assembled on this base and the tip of a spiral spring is hooked over each of these intersections, the springs at this stage standing upright and unattached on the base. The large top coils of these springs must now be connected into a single surface to form the supporting surface of the spring. This is done by running straight wires longitudinally between each row of top coils of the spring and attaching the springs to these wires in pairs, at their points of contact, by small metal clips. Finally a heavy border wire is attached by the same style of clips, around the outside row of springs. The assembled spring is then tempered in an oven, dipped in enamel and baked in the same oven. These processes are summarized in the table below (Figure 20).

The results of such an analysis as this indicate the order in which the various operations are to be performed, the machine capacity and time required, the necessary tools, the exact method of operation (which is embodied in working

FIG. 20

ANALYSIS OF SPRING MODEL NO. 441.

Part Symbol	*Part name*	*No. per bed*	*Material required*	*Opn. No.*	*Operation, name*	*Machine or work place*	*No. of men per mach.*	*Output in parts per hr., or time*
441	Finished bed spring		1 Base 441-B 90 Springs 441-S 1 Border 441-D 9 Bot. crimp 441-CB 8 Top crimp 441-CT 90 Clips 441-L					
				1	Final Assembly	Assembly bench	2	2
				2	Temper.	Oven, capacity 30 Springs	0	One charge takes 1 hr.
				3	Dip.	Tank	2	30
				4	Bake	Oven	0	One charge takes 1 hr.
				5	Crate for shipment	Crating machine	1	10
441-B ...	Base	1	2 Side rails 441-B1 10 Cross slats 441-B2 9 Center braces 441-B3					
				1-B	Rivet braces to slats, rivet slats to side rails	Riveting Bench	1	5

441-B1...	Side rail	2	Angle iron 1¼" x 1¼". Carried in stock cut to length	1-B1	Punch 10 holes	Gang press	1	120
441-B2..	Cross slat	10	1" No. 10 Band iron	1-B2	Cut to length punch holes	Gang press	1	200
				2-B2	Twist and bend ends	Bending machine	1	300
441-B3..	Brace	9	1" No. 10 Band iron	1-B3	Cut from stock	Gang press	1	300
				2-B3	Bend ends	Bending machine	1	300
441-S ..	Spiral springs	90	No. 10 Premier wire	1-S	Coil	Coiling machine	1	1,000
			4 ft.	2-S	Knot top coil to close spiral	Knotting machine	1	500
441-D ..	Border	1	21 ft. No. 3 Prem. wire straightened closing ferrule	1-D	Form border and join ends with closing ferrule	Forming table	1	60
441-DF .								
441-CB .	Bottom crimp	9	No. 11 Acme wire, 6 ft., straightened and cut to length	1-CB	Dent	Crimp machine	1	300
441-CT .	Top Crimp	8	Same as 441-CB	1-CT	Dent	Crimp machine	1	300
441-C ...	Clips	90	Carried in stock ready for use					

instructions) and other important production information. Such studies may conveniently be embodied in standard instructions or route sheets, of which two typical examples are illustrated below. It will be noticed that the recording of practically all information, as to method, drawings, tools, piece rate, machine and alternative machines, material needed, etc., is provided for. Figure 21 is modeled after a route sheet

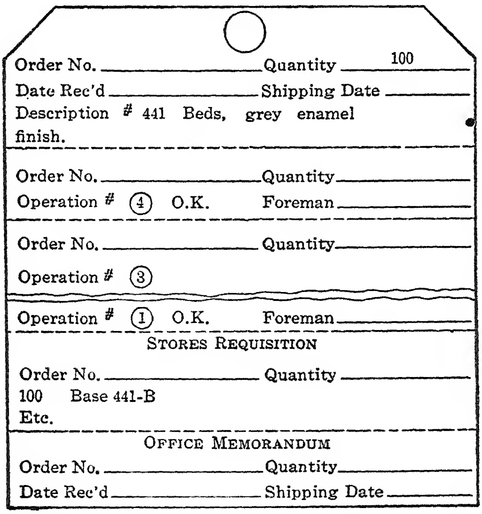
ROUTE SHEET Description *Base, 441 Single deck Clip top spring*				Part Symbol *441 B*	
Drawing No.				Order No. *225* Quantity *1000* Date Ordered *10/1* Date Wanted *12/1*	Order No. Quantity Date Ordered Date Wanted
Operation No.		Machine Number	Piece Rate or Time		
Binding Edge	List of Materials required				(This space used for record of the next lot made)
	2 Side rails 441-B1				
	10 Cross slats 441-B2				(Check marks showing material in stock)
	9 Center Braces 441-B3				
	27 R. H. Rivets 3/8" x 3/16"				
6	*Rivet braces to slats, rivet slats to side rails*	*B-27*	*.18 ea.*	Jan. 1, 1922 (Date stamp showing operation completed)	

FIG. 21.

ROUTE SHEET.

designed by Carl Barth as part of an installation of the Taylor system. Space is provided for the entry of several orders on this sheet, the sheet serving as a combination route sheet or standard instruction, and progress record. As each item of material is checked as ready, or each operation is completed, a line is drawn closing the corresponding space in the check column, indicating at once just how far the order has progressed. A somewhat simpler type, useful where opera-

tions are well standardized and detailed instructions are not necessary, is the so-called "stub tag" shown in Figure 22. This tag is of cardboard and is attached to the lot, indicating where the material is to be moved for the next operation, and giving a standard operation number. Each stub, as the work is completed, is torn off and sent to the office, where it may be used to check progress of the order if desired, and also as



Order No. ______ Quantity 100
Date Rec'd ______ Shipping Date ______
Description # 441 Beds, grey enamel finish.

Order No. ______ Quantity ______
Operation # 4 O.K. Foreman ______

Order No. ______ Quantity ______
Operation # 3

Operation # 1 O.K. Foreman ______

STORES REQUISITION

Order No. ______ Quantity ______
100 Base 441-B
Etc.

OFFICE MEMORANDUM

Order No. ______ Quantity ______
Date Rec'd ______ Shipping Date ______

FIG. 22.
STUB TAG.

a record of piece-work earnings. For standard jobs these tags may be run off in quantity, the order number, date of delivery, quantity, etc., being filled in for each tag as needed.

Route Clerk.—The route clerk, who prepares these operation analyses, often works at a desk in the shop planning office, to which come the blue prints, samples and bills of materials for each new job. It is his task to dissect the product and visualize the method of performing each opera-

tion. Shall this bearing pin be turned down from stock on a lathe, or drop forged, or cut from cold rolled bar stock? Shall a milling cutter be used for this operation, or a planer? Shall this printing job go to the big rotary press, or will it be more economical to run it on the smaller Gordon presses? The work of operation analysis is a key position of great practical importance in effective and economical special order manufacture. The men selected for this work should have shop experience in their special production lines, and should be selected for imagination, analytical ability, ability for

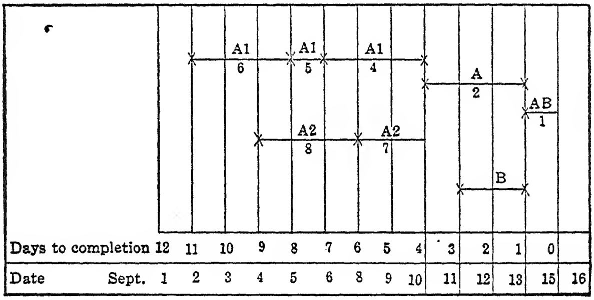


FIG. 23.
ASSEMBLY DIAGRAM.

sustained concentration, mechanical sense and interest, and an intelligent understanding of the whole routine and system of the factory. Foremen of the right type or shopmen of an inventive and mechanical turn of mind often make good route clerks. An important part of the work of operation analysis is also the "tooling" of the job, the selection, or design where necessary, of the proper tools, jigs, fixtures, and accessories needed for the job. Also the determination of standard times and the work of detailed motion study and analysis, to improve operating methods, are closely associated with the work of the route clerk. Special consideration will be given to these duties in subsequent chapters.

Assembly Diagram.—The information about the product given in the operation analysis can be put in the form of a diagram which shows very clearly the sequence of operations and time required. In this so-called assembly diagram the time necessary for completion is shown by horizontal length of line. Figure 23 is an idealized diagram showing the facts for a product AB, assembly, part A being in turn composed of parts A1 requiring three operations as shown, a total of seven days, part A2 two operations, five days, the assembly of A requiring three days, the making of B requiring two days, and final assembly, one day. The following tabie is a brief summary of the operations:

Part	*Composed of*	*Operation No.*	*Time required*
AB	A, B	1	1 day
A	A1, A2	2	3 days
B		3	2 "
A1		4	3 "
		5	1 day
		6	3 days
A2		7	2 "
		8	3 "

All of the information given on the assembly diagram is already contained on the route sheet, and it is generally not necessary, where the user is thoroughly familiar with the product, to take the time to put it in the form of the assembly diagram. This diagram is however a useful method of giving a clear picture of what is involved in the analysis and time control of a product.

Considering the simple case of a factory making only one product, it is evident that the facts contained in the route sheet and assembly diagram, whatever the actual form in which they are recorded, are the basic facts on which the factory and organization are planned and built. The assem-

bly diagram gives a key to the layout of the shop machinery and processes, and in Chapter VII is given a drawing showing, in simplified form, how the layout is based on the diagram.

The diagram shown in Figure 23 also gives a key to the time requirements for scheduling, and assuming the conditions as represented, indicates the starting time for each operation. If an order were to be started through the shop in time to ship on the morning of the sixteenth, work would evidently have to be started on A1, the part earliest needed, on the second; B would not need to be started until the eleventh. Properly modified the diagram would show the facts for any situation.

Where more than one article is being manufactured the situation is more complex, but it would still be possible, for each product, to make an analysis of operations and of operation time requirements, and to total the requirements for all operations for a given average output of each. The further development of the use of the information which we have here given pictorially in the assembly diagram will be taken up in later chapters.

Combined Routing and Clerical Procedure.—F. W. Taylor and Carl G. Barth are responsible for an ingenious and economical system of preparing shop written orders and instructions, in a special order industry. In this system a bill of materials was prepared from the customer's original order by the engineering department, and, with the drawings of the job, was sent to the planning department. Here the route clerk prepared and had written on the typewriter in copying ink, a standard route sheet, whose heading bore the customer's name and address, date of receipt of the order, shipping date promised, and such other details as were necessary in the particular case. In the body of the bill the order and item number, the number of pieces, and description were given for each part called for on the engineering department's bill. Also, after the description, for each item a condensed operation layout was given by symbols or description. Figure 24

illustrates this master bill, and Figure 25 shows the route tag prepared from one item of this bill.

Sold to	*John Doe, Detroit, Mich.*	Our Order No.	*R 2100-1*
		Customer's No.	*247*
		Sold by	*F.B.J.*
		Date sold	19
Description	*One # 311 C transmission, Complete with housing.*	Date promised	19
		Date delivered	19

Item No.	Order No.	No. Pcs.	Pattern No.	DESCRIPTION
1	*R 2100-1*	*25*	*311-C-6*	*18" 11 tooth gear, bore, turn, key seat, grind*
2	*R 2100-1*	*25*	*311C-11*	*2" x 4'0" shaft, cut-off, key seat*

Forms required

3 B/M	DB 1	*10* time cards	DB 16	__ foundry order	DF7
1 cost copy	DB 2	*3* requisitions	DB 22	*1* route sheets	DB9
1 shp'g copy	DB 4	*3* route tags	DB 8	__ route sheets	DB10

FIG. 24.

MASTER COPY, BILL OF MATERIALS.

From this master bill copies were prepared for the planning department file, for each general foreman having work on the job, for the shipping clerk, the billing department and

Form No. DB8

ROUTE TAG

These items are duplicated from item 1, Fig. 22 →

Order No.	No. Pcs.	Patt. No.	Description
1 R 2100-1	*25*	*311-C-6*	*18" 11 tooth gear, bore, turn, key seat, grind*

These items are filled in by hand →

Operat'n	1	2	3	4	5	6	7	8	9
Operat'n Symbol	*BB1*	*CT39*	*KS1*	*GG34*	*Insp.*	*Packing Room*			
Machine Symbol	*DB28*	*DL10*	*DK16*	*DG4*	*Insp.*	*Pr.*			

FIG. 25.

SHOP TAG.

the cost department, the copy for the latter being duplicated on a special form which provided columns for the extension of costs on each item. From the same master bill a set of

forms was run off for each item, a time card for each operation, a stores requisition, a route tag (Figure 25) (attached to the job for identification) and foundry orders or other special forms as required. A very little additional clerical work then completed each form ready for use, and the forms were then filed away in suitable "waiting time card" and other files, ready to be drawn out and placed in the machine schedule board, or otherwise used, as the job progressed.

A full description of a similar system used by the Link Belt Company is given in "Scientific Management" by C. B. Thompson.

Classification of Manufacturing Processes.—Frederick W. Taylor, in his paper on "The Art of Cutting Metals," and Carl G. Barth, in his supplement to this paper, have shown that it is possible to reduce practically all of the various operations involved in cutting metals to the simple case of the application of a cutting edge to the metal. Thus, whether the tool is the point of a lathe tool, the edge of a drill or the tooth of a milling cutter, the laws governing its efficiency will be the same, and there will exist the same definite relations between the shape of the cutting edge, its hardness, speed and depth of application, and the amount of metal removed per hour, and life of the tool. Similarly the tools for woodworking bear many similarities to those used for cutting metals, many of these tools, such as the chisel, saw, drill, milling or carving tool, etc., being of practically the same form except for the differences in strength and speed dictated by the relative hardness of the materials worked.

It is possible to reduce nearly all of the processes met with in manufacturing to a comparatively small number of basic elements, repeated over and over in varying forms and combinations. Such a classification will at times throw together processes having little in common and will at times overlap. Yet to the beginner it will be of great help in understanding and analyzing the apparently bewildering complexity of manufacturing operations, and to the advanced worker it will often

suggest fruitful analogies between the problem he is working on, and problems which have been successfully solved in other fields. The following classification, while not complete, will offer the reader a suggestion along these lines.

A CLASSIFICATION OF MANUFACTURING PROCESSES

1. Power Generation and Transmission.
   - a. Heat engines and prime movers, water power, fuels and heat sources.
   - b. Transmission.
     - Electrical—Dynamo, motor, transformer, etc.
     - Mechanical—Gears, belts, levers, shafts, etc.
       - Pumping fluids, compressed air, water, etc.
2. Conveying and Storage of Materials.
   - a. Lifting, conveying, pumping, gravity movement, blowing, etc.
   - b. Storage.
3. Change of Form.
   - a. Change of composition or structure.
     - Heat treatment—Freezing, fusion, evaporation, drying, tempering, annealing, baking, chemical change.
     - Chemical processes—Solution, digestion, bleaching, light action, electrolysis, washing, etc.
   - b. Change of shape by pressure or cutting.
     - Blunt tool—
       - With heated or plastic materials—Forging, rolling, extrusion of metals, brick forming, etc.
       - Cold working—Hammering, wire and press drawing, bending, metal spinning, etc.
       - Crushing—Ore crushers, flour milling, paint grinding, etc.
     - Edge tool—
       - May be classified by hardness and characteristics of material cut, thus—Metal-working, woodworking, cloth, paper, etc.

Edge tool—(cont.)

May be classified by power applied, thus—Hand tools, speed tools, geared machine tools, etc.

May be classified by number of cutting edges, thus—

One cutting edge—Chisel, knife, scraper, lathe, planer and shaper, etc.

Multiple edge—File, milling cutter, wood carving cutter, saw, reamer, broaching tool, etc.

Two opposed edges—Shear, punch press, etc.

May be classified as to whether tool or work is the primary active or moving element, thus—

Tool active—Saw, shaper, drill, milling cutter, press, etc.

Work moved—Lathe, planer, boring mill, etc.

Grinding and abrasive—

Grinding wheels, sand paper, sand blast, tumbling, polishing, etc.

c. Casting and molding of liquid and plastic substances.

Casting—Foundry, type founding, die casting, cement pouring, etc.

Molding plastics—Glass blowing and molding, rubber, celluloid, ceramics, etc.

4. Processes Primarily Analytic or Separative.

a. Chemical—Distillation, electrolysis, precipitation, etc.

b. Mechanical—Sorting, sifting, filtering, screening, gravity or centrifugal separation, magnetic and electrostatic separation, etc.

Cutting, splitting, etc.

5. Processes Primarily Synthetic or Combining.

a. Chemical combination—With heat, mixture, electrical action, ferments or catalysts, etc., as adjuncts. Alloys.

b. Mixture—Paints, inks, cement ingredients, etc.

c. Coating or surfacing processes.

Electro-plating, tinning, galvanizing, etc.

Painting, enameling, varnishing, etc.

Coating may be applied by dipping, spraying, brushing, etc.

Oxidation, fuming, and other chemical coatings.

Dyeing, printing, impregnation.

d. Combination by twisting or weaving.

Spinning and twisting—Rope, thread, wire, cables, etc.

Weaving—Of cloth, wood or metal fibers, etc.

Knitting.

Felting—Felts, papers, etc.

e. Combination by fastenings.

Adhesives—Glues, cements, pastes.

Nails, rivets, bolts, screws, pins, etc.

Sewing, stitching, book binding, tailoring, etc.

Welding, soldering, brazing, etc.

f. Combination by fitting or assembly.

Using fastenings as in (e).

Fitting together, as in many machine assembly processes.

Packaging and wrapping.

6. Measurement, Testing and Inspection.

a. Counting.

b. Checking by inspection for correspondence with standard, measurement.

c. Performance tests.

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CHAPTER VI

PLANT AND EQUIPMENT

Location.—The choosing of the location for the factory, while an infrequent problem, is one of great importance because of its very infrequency, since once located it is most costly to change, and every unit of product will have to carry permanently the cost of a mistake. Correct location is the balancing of a number of factors, often opposing, and the selection of a site for which the balance of all factors is the most favorable.

Transportation Costs.—Transportation costs constitute an important element in the location. It costs a certain amount to get the raw material to the factory, and from this standpoint that location would be best which put the factory at the source of supply, or at the best average point in case several commodities, including coal or power, must be brought together.

From the standpoint of getting the product from factory to market, however, time is saved and quick deliveries are made possible by getting as close as practicable to our market—usually a location in or near a large city, in itself a large market, and providing special facilities in the way of through freight service, package cars for less than carload lots which run direct to distributing points without stop, frequent mail and express service, and similar facilities for quickly reaching a considerable territory.

Two processes may take place in manufacturing, from the freight standpoint—first a reduction in weight of the product as in smelting metal ores or sawing logs, second an increase in bulk, value, and fragility which causes the article to take a

higher freight "classification," and consequently increases the cost per pound for freight. Usually an industry in which the reduction in bulk is preponderant, as in sugar extraction, lumbering, mining, etc., will locate at the source of materials, while one in which the increase of classification is important will get as close as possible to markets. Thus the Ford Motor Company manufactures unit parts (which can be compactly packed with little increase of bulk) at central plants, and assembles its cars in numerous assembling plants throughout the world, each at the center of a distributing district. In a case such as this the problem is evidently one of balance between the economy of quantity manufacture due to large scale production, and the saving in freight rates by localization of the manufacturing unit. As Mr. Ford points out in his Autobiography, there are important social reasons for decentralizing production and getting away from the congestion, high cost and bad living and labor conditions of the city for the factory worker, and the tendency toward decentralization is a hopeful one. It is, however, in considerable part a matter of mathematics—of freight rates and distribution costs and necessities. The manufacturer who produces in sufficient volume to maintain a number of factories, each large enough to be an economical producing unit, finds it possible to scatter these units. The maker of a staple article which may be sold from stock can locate away from his market in some little town, if freight rates are satisfactory, where living conditions and stability of force are better than in the large city, and taxes and cost of land and often of building are lower. The man who makes up goods to customers' special order, however, usually finds it advantageous to locate in the large city so as to be able to fill orders with the least possible delay.

A phase of the transportation problem in location is that of competition. If, on a map, points of equal freight rates were to be plotted about a prospective location, a series of zones would be formed, each zone indicating an increased freight

cost. A similar chart of rates for a competitor in another city would indicate by the intersection of zones, a territory in which one location has the advantage, a territory which approaches neutrality, and one in which the competing location has the advantage. The small business can sometimes get a local foothold from which to grow to larger proportions, by locating in some territory formerly served from more distant points by national distributors, and by using the freight and service advantages, and often the local patriotism appeal, to offset the advantage of quantity production enjoyed by its larger competitor.

Labor Supply.—A second vital problem of location is that of labor supply. Here we meet two interesting questions, that of regional specialization, and that of urban versus suburban, small town and rural conditions. About ninety per cent of the collars and cuffs made in this country come from Troy, N. Y. Forty per cent of domestic carpets and rugs come from Philadelphia. The two states of Pennsylvania and Indiana produce over half the glass made in the country. Brockton and Lynn, Mass., are large producers of shoes, Fall River, New Bedford, and Lowell, Mass., of cotton goods, Paterson, N. J., of silk goods, Chicago of agricultural implements and meat products, Waterbury, Conn., of brass goods, Detroit of automobiles, Akron, O., of rubber goods, Pittsburgh of iron and steel, New York of women's clothing. Sometimes a reason for this localization is found in proximity to raw materials, or to special climatic or other advantages. But most frequently the preeminence is simply the result of a gradual building up from more or less casual beginnings. A colony of glovers from England settled in Gloversville, N. Y., and made that town one of the large glove producers of the country. As the industry establishes itself it offers to newcomers in the same line the advantage of trained workmen, available in adequate supply, and of a development of special facilities such as the auxiliary industries which manufacture automobile parts and do ex-

perimental work, build tools, and develop special paints and varnishes, for Detroit's automobile industry. Special shipping and banking facilities develop. Advertising advantages accrue as the region becomes noted for a product. Trade associations are formed. All of these advantages tend to give impetus to the concern which locates in the specialized region.

From the standpoint of labor supply, the question of choice between the urban and the rural community is important. The large city has the advantage of a large market for and supply of labor. Street car and suburban trains make it possible for many thousands of prospective employees to obtain access to the plant, and it is nearly always possible to pick up quickly any number of employees in almost any occupation. For the large industry with irregular or seasonal operation, the city also furnishes a reservoir to absorb, with the least serious economic loss, the men who must from time to time be laid off. In the small town the layoff of a hundred or several hundred men might well be a calamity, prostrating the business life of the town and compelling the men to dispose of their homes and seek employment in other towns.

On the other hand, the small town is the ideal place, from the standpoint of labor supply, for the steady industry. Living is usually cheaper and less cramped, time and effort spent in going to and from work are less, the men can own homes, become citizens instead of floaters, the influences making for discontent in the minds of the men are less.

Other Factors.—Certain other factors must also be considered in location. In special cases the need for suitable climatic conditions (as in spinning cotton), for abundant water (as in pulp and paper manufacture), for cheap electric power, or for similar special requirements will dictate the location. Special inducements are often offered by communities in the way of houses, sites, loans, subscriptions to stock, free power, or remission of taxes.

Once the general location is chosen the question of site must be considered. Location on or near a railway siding is usually

important, saving many dollars in cartage and freight charges if well chosen. The plant must be within convenient walking or car-riding distance from the workers' homes, and available for gas, water and electric connections and prompt fire protection service. The saving by buying cheap outlying land and the possibility of easy expansion of the factory site must be balanced against the convenience of a central location from market, freight, and labor standpoints. The building should be kept at a safe distance from other buildings, especially inflammable ones where practicable, to reduce the fire hazard. Ground should be chosen which will not entail a great expense in grading, sinking foundations, etc. Where it is not known how a new business will develop it is often best to rent until special needs and capacity are more definitely known. Often a company finds it more profitable to occupy a rented building on a long lease than to invest any portion of its capital in a building.

The Plant.—Several types of factory construction are met with. One of the commonest is what is known as the "mill type," walls and main partitions being of brick, floors and roof of two or three-inch plank laid on heavy joists ten to fourteen inches deep and four or more inches wide. These heavy timbers burn through slowly in case of fire, often holding up better than poorly protected steel beams, which warp and sag. The supporting timber columns are carried up from foundations to roof in a straight line, and the cross beams and joists are supported in cast iron pintles or saddles in such a way that in case of fire one section of floor, in burning through and falling, will not carry the supporting columns with it. The heavy joists, spaced widely apart, permit a stream of water to reach the ceiling successfully. This type of construction has the advantage of being cheaper than the other types.

Reinforced concrete makes an excellent structural material, the whole building being poured a floor at a time, into a monolithic structure. Such a building is durable, absorbs

vibrations because of its weight, and is about as near fire proof as can be obtained. Brick paneling is often used to obtain architectural quality and finish in such a building, and large steel-sashed windows may form a considerable part of the outside wall.

Structural steel with brick or tile fire-proofing is another favorite framework for factory buildings, especially where heavy craneways must be provided for.

Fire Protection.—From the standpoint of fire protection certain general precautions are observed in building. In the first place, an automatic sprinkler system is usually provided, with sprinkler heads at fixed intervals, so arranged that heat will melt a fusible link and release a spray of water. Water and chemical extinguishers should also be provided, and placed near the points at which they are likely to be needed. Electric wiring must be enclosed in suitable conduits. Openings from one floor to another such as beltways, chutes, etc., are in general not permitted unless protected by self-closing metal doors. Elevator shafts especially should be completely enclosed in metal, or wire glass. The building should be cut off into sections at intervals of approximately one hundred feet by fire-proof brick walls, continuous except for openings with self-releasing metal fire doors. Emergency exits, non-inflammable and either outside the building or completely enclosed in a fireproof well with metal doors, must be provided for workmen.

Lighting.—Good lighting is an essential to good work. Diffused daylight is the best illuminant, and probably the best illumination is given by what is known as the saw-tooth roof, which consists of a series of east-and-west ridges, of which the long southern slope is roofing, and the abrupt northern slope is glass. This roof is, however, expensive in first cost and maintenance, rather hot in summer, and limited to one floor.

To secure adequate lighting from the sides the building should not be too wide—probably not over sixty to eighty feet with ordinary heights of ceilings. The ceilings should be high

and kept clear as far as possible of belting and obstructions, particularly near the windows. Walls should be covered with whitewash, mill white, or some other non-inflammable white paint. The operator at the individual machine should preferably receive light from at least two sources, the strongest light coming from the side. He should not, if it can be avoided, face the glare of a sunny window. Machines and processes requiring fine work should be placed next to the windows, while the central space should be used for aisles, storage, and similar less exacting purposes. Artificial lighting is usually provided as (1) a general illumination providing a moderate degree of light intensity throughout the whole working space and (2) more intense illumination at the points of work. Indirect illumination, in which the light is reflected from bowls to the ceiling and from the ceiling to the room at large, is the best but also the most costly method of lighting. A system meets reasonable requirements which illuminates the whole room brightly enough so that there are no dark corners or black shadows or violent contrasts between lighted portions and the general area of the room, which protects the operator's eyes from the direct glare of the bulb, and which provides a sufficient intensity where needed for fine work. Enameled steel reflectors, cupped enough to shield the eyes from the light source, are satisfactory.

Other Elements.—Temperature, humidity, and ventilation require control. The correct working temperature will vary from sixty degrees Fahrenheit for shop work to seventy or seventy-two degrees for office and sedentary work. In some of the most modern plants, especially where dust would injure the product, as in food manufacture, or varnishing rooms, air is drawn in, is washed by a spray of water, is heated by steam coils, and driven by a fan into the working rooms.

Sanitary provisions should include a locker or clothes rack space for each employee, cool sanitary drinking fountains where needed, and toilet and wash stand or wash trough space sufficient for the force employed.

Power and Auxiliary Services.—The modern factory may require power, conveyed by shafting or electricity, compressed air connections for portable tools, blowing, etc., gas or fuel oil for furnaces, steam for heating and special purposes, a circulating system for machine tool cutting compounds, and annunciator or signal system, interdepartment telephones, and other possible means of communication and supply. The planning of the building must include provision for all these needs. Usually in such generally used services as water and electricity, it is well to lay out the whole building with a unit system of outlets, so that a complete rearrangement of connections would be possible without relaying mains.

Electric power is very largely used because of its flexibility and the elimination of the heavy, power-absorbing line shafts, which had to be kept running even if only one machine was in use. The modern system is either a series of short jack shafts, each belted to a motor and driving a related group of machines (as one department or a bank of machines of a kind) or an individual motor for each machine.

Individual motor drive is at present limited principally to cases where very flexible speed control or other special considerations exist, since by belting several machines to one shaft a better load factor is obtained and it is possible to use a motor of smaller horse power than the combined horse power of the group. The inertia of belting, shaft, and the other machines of the group also helps to absorb and even out the sudden pulls of such machines as punch presses, which run idle for all but a fraction of the cycle and exert a very heavy pull for this momentary fraction.

With the increased availability of central station power, with low rates for power users, the small and medium sized manufacturer often nowadays buys his own power, the only use for steam being for heating purposes.

Safety requires that belts, gears, and other dangerous moving parts shall be guarded so that the hands, clothing, or hair of the operator cannot become entangled in them. The impor-

tance of this work is such that the large plant usually has a safety department specially to supervise it.

Handling of Materials.—Almost as important as the actual processing, in economical manufacture, is the efficient movement of material from process to process. There are two requisites to this movement, first, places to put the material not actually in the machine, and, second, means of getting it moved to the next operation.

Storage of the reserve stocks of raw materials and finished parts is a specialized function to be later described in detail. Work in process is usually kept together in one lot, for small lots, by placing it in steel pans of convenient size, which may be dragged over the floor with a hook, or for larger lots is handled by piling it on platforms or on tote boxes which may be lifted by a lifting truck or crane and readily moved to the next operation without reloading or rehandling. A full box and an empty one are provided at the machine, and the work as completed is transferred to the empty one. In most intermittent processes there is a general probability that several lots may accumulate at one machine waiting their turn for operation, and to provide for this it is necessary either to provide extra space around the machines, or a central series of racks or piling spaces within convenient reach of the machines. Where heavy parts requiring the use of a crane are handled, the machines are often placed on each side of a central bay, which serves as a storage and assembly floor.

Movement of Materials.—Material handling devices may be classified, from one standpoint, according to the degree to which the device is specialized to perform one kind of movement only, or is adaptable to handling a variety of materials, or to transport over a variety of routes. In the flow repetitive industry most of the equipment will be narrowly specialized, a link which serves one purpose only in the chain of production. In the intermittent types the equipment must be adaptable to various purposes, efficiency of movement being sacrificed if necessary to flexibility.

The various chain and belt conveyors are typical of the specialized class of conveyors. In these conveyors a continuous belt or linked chain runs between two points on power-driven pulleys or sprockets, and carries the material by means of buckets, hooks, or grapples attached to the belt, or carries it directly on the surface of the belt itself, the edges of the belt often being dished up in the latter case by pulleys or guides, in order to hold more of the loose material handled thus. Material is often processed or assembled while being moved slowly by one of these conveyors over a bench or platform, one or a group of operators working in fixed positions alongside, and processing each article as it passes. Conveyors of this sort may be used as elevators or escalators for conveying persons, and also may be adapted for handling bulk material such as coal, dirt, ore, ashes, small parts, for conveying packages, boxes, barrels, meat carcases, and almost any other conceivable material. Portable conveyors are in use for loading materials into cars, wagons, etc., for piling lumber, and for similar purposes. Among other types of single-line specialized conveyors may be mentioned the gravity chute, a straight or spiral sheet-iron chute extending from one floor to another, in which the material is slid down by gravity. It is possible to use dividing switches, by which in a long spiral chute extending from top floor to bottom, materials may be stopped and emptied out at intermediate floors. Sometimes several spiral chutes are wound around the supporting axis of the conveyor, opening, for example, at first, second, and fourth floors, or as desired. Self-closing doors or covers must be provided at each floor for protection against fire. Materials are also sometimes moved by compressed air or vacuum, either directly by blowing or in cylindrical containers similar to the vacuum tube cash carriers in use in many stores. A revolving worm or spiral blade is also used for finely divided materials or liquids, and various types of pumps for liquids.

Among the less specialized types of conveyors we find sev-

eral prominent types—the hoist, for straight lifting, the crane, for combination lifting and horizontal transportation, the hand truck and tote box, the power driven truck and tractor, the locomotive (a tractor running on tracks) the overhead trolley or monorail, and many combinations of these.

For handling and keeping together small lots of material some type of pan or tray is most convenient. This may be simply a sheet iron box shaped like a bread pan and about two feet long, with a hole punched in each end so that it can be dragged by a hook. Or it may be divided into compartments, so that when filled it contains a fixed number of parts, say one hundred. This type saves counting, prevents injury to delicate parts, and positions the material for rapid work at the next operations. Sometimes a special rack such as Gilbreth's "packet" is used, which contains just enough parts for an assembly, each part arranged in order of assembly so that it may be conveniently grasped by the workman.

For larger and heavier lots a platform about three feet square or a box three feet on each side may be used, being elevated about eight inches from the floor by wooden skids attached to the bottom. One of the various types of lifting conveyors is then used to move the load, being slid under the box or platform and the latter lifted off the floor by a lever device by which the platform of the truck can be raised sufficiently to clear the box from the floor. For limited movement on a smooth floor, the trucks may be mounted directly on casters or small wheels. A very convenient type of platform is one about thirty inches high, or of just the right height to be slid up next to and even with the working point of a punch press or other machine so that stock can be piled from the machine without unnecessary motions.

Numerous other special forms of trucks are found, which make possible considerable labor saving. Thus for drying furniture and piano parts after varnishing, a high rack with a series of horizontal projecting arms is used, the parts being laid on the truck to dry and moved to the next operation with-

out re-piling. In handling pianos and automobile bodies a tilting truck is used, with a projecting steel edge which may be inserted under the body to catch it, so that one man can tilt it and handle it alone. Considerable labor may be saved by planning heights of machinery so that uniform trucks will serve any machine and by laying out the trucks with special reference to the operations on the product. Sometimes it is possible to leave material in definite sized lots in tote boxes or on trucks even in storage, thus saving the cost of handling into and out of storage bin or pile.

The industrial tractor varies all the way from the typical hauling truck of the streets to the Ford chassis with cut down wheels, or the squat heavy electrically driven unit capable of coupling up a load of trailers, and either pushing or pulling.

Serving somewhat the same purpose as the tractor but less flexible as to route is the suspended monorail car. This unit usually is equipped with a system of tracks and switches by which it may serve any desired territory, and has a hoist for picking up a heavy casting, a box of parts, or any other desired load.

The crane is found in several forms. One type, the overhead or gravity crane, is essentially a hoist mounted on rollers and running the length of a long horizontal beam, the beam itself having rollers at each end and moving at right angles to the travel of the hoist, on two parallel rails. In the overhead crane these rails are fixed to supports such as the columns of a building, at a height above the floor. In the gantry crane, used mainly in outdoor yards, the track is above the ground, and the beam of the crane is elevated by mounting it on high struts, which have rollers at their bases and may be moved along the parallel tracks. This type of crane is useful for handling heavy objects over the area included between the tracks on which the crane runs.

A second type of crane is the jib crane, in which a horizontal arm with a hoist at the end of it, is pivoted to the base of a mast so that it may be swung in a circle about the pivot or

raised at any angle to the central mast. This type serves within a circle whose radius is the length of the swinging arm or boom. A scoop or clamshell bucket attached to the end of the boom adapts this type to digging or loading material. The whole outfit is often mounted on a car or tractor. A variation of the crane is a tee beam suspended so as to swing horizontally about a pivot, with a trolley running along the horizontal flanges of the tee beam and carrying a hoist. This type is useful for serving individual machines where the work is heavy.

The hoist may be simply a block and tackle, or there may be combined with this an air- or electrically-driven motor. A special form of the hoist is the elevator, in which a platform is lifted by block and tackle, or winding drum, or sometimes by hydraulically driven steel plungers which support the platform from beneath. Separate passenger and freight elevators are usually provided. The freight elevator is rather a costly method of transportation for small lots of material, as it usually has to return empty, uses power whether loaded to capacity or with a package of bolts, requires a special attendant, and does not operate very fast. It should be the general purpose or reserve conveyor in most although not all cases, special chutes or conveyors being used where any material is frequently handled in small volume. A good plan which will be referred to later is to move all material to the top floor in bulk on the elevator, and to let it move downward by gravity in chutes such as those described.

A special type of elevator is the piling machine, a portable elevator with a base on wheels and a projecting platform which may be elevated to pile stores, boxes, etc., heavier, higher and closer to the ceiling than could be done readily by hand.

Principles of Handling.—Two or three principles of material handling may be briefly noted. One is that as far as possible material should move in the shortest straight line from the first process to the last. The effective length of line here is really the cost of handling from one point to another.

Liquids, for example, may be moved much more cheaply per unit of weight and distance by pumping than solids can be moved by hand-trucking.

A second principle related to the first is that where there must be a choice of positions, processes should be so laid out that parts used in quantity, or parts heavy and costly to handle, should receive preference. Thus in a foundry, large castings which require costly handling by crane would be put in the most favorable position for loading into cars or storage. And in laying out a group of machines for a variety of products which followed various paths, the layout would be made primarily with reference to the product made in largest quantity. A third principle or device is similar in idea to the method used in handling mails. Where inter-plant correspondence, or materials, move frequently in various directions, instead of sending a special messenger or conveyor for each item it may be possible to establish regular routes, a collector calling periodically at prearranged times, picking up items, assorting them, and dropping them at the proper point in his rounds.

Figure 1, at the beginning of the book, is a photograph of one stage in the assembly of the Ford car, which illustrates several details of building construction as well as the general idea of progressive assembling. Notice the concrete building construction, which is painted white for better lighting, and the fire protection by sprinkler pipes and nozzles overhead and by extinguishers. In addition to the lamp shown, general illumination at night or on dark days is provided by clusters of lights placed high between the ceiling beams, with enameled steel reflectors. Windows are steel sash and of large area. Notice the various material handling devices shown, and the extensive use of special jigs, tools, kits for parts, and other special devices for improving the efficiency of the workmen.

Further reference to the method of controlling the movement of materials will be made in Chapter XI on scheduling.

Insurance.—Protection of the physical and other assets of

the company is an important matter. Among the various kinds of insurance in general use by manufacturers may be named Fire Insurance, and where the locality makes it advisable, Tornado Insurance. Employer's Liability Insurance has also become practically universal since the various states have enacted legislation setting fixed rates of compensation for injuries sustained while at work, and requiring the furnishing of bond by the employer for the faithful performance of the awards of state Industrial Compensation Boards. Other forms of insurance are also sometimes used, such as Life Insurance on executives or men of special importance to the organization, Credit Insurance as protection against more than a certain percentage of bad debt loss, and other forms.

Fire insurance rates must be carefully considered in planning the buildings and layout of machinery, in order that the building may conform to the most favorable rate classifications. Thus one Sprinkler Fire Protection Company offers to put in complete sprinkler protection systems with no initial payment, expecting in two or three years to pay for the system from the savings in insurance. Similarly the adequate safeguarding of machinery, use of non-slip stair treads, guarding of openings, elevators, and electrical switches and machinery not only reduce accidents but affect the insurance rates.

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CHAPTER VII

LAYOUT AND EQUIPMENT

In Chapter IV a method was described for analysing the product, graphically or otherwise, first into conponent parts, then—for each of these parts and for the whole—into operations in proper sequence, and finally, for each operation, for determining the time required for its completion. If we have the information given by the estimate of sales as to the output for which provision must be made, and the facts given by the assembly diagram as to machine capacity and order of process, we have, at least in theory, all the information essential for planning and equipping a factory. Practically the sales estimate is affected by many contingencies and possible expansions for which allowances must be made, and since we frequently have several products to make and in varying quantities, the actual purchase and layout of equipment is a combination and a compromise between the needs of the various products and the limitations of building spaces, power distribution, lighting and other factors. But the basis of all sound layout of equipment is the assembly diagram.

The first step in layout of equipment is the translation of the list of operations given by the route sheet, into terms of a table of machine hours, derived from knowledge of the capacities of the various machines, which in turn is secured from experience or the manufacturer's ratings of capacity. Knowing, for example, that to produce the required output will take one thousand hours at operation number three (as the case may be), it is a simple operation to estimate the number of machines (one hundred, with a ten hour day), required for this process. Various allowances must be made,

for Saturday afternoon, holidays, and interruptions and idle time from such causes as breakdown of machine or absence of operator.

We next obtain from the manufacturers, or by observation or experience, a table of space requirements for each machine. Included in the space requirements should be not only the foundation space of the machine, but working space for the movement of the operator and an allowance for the storage and working space normally required.

By a somewhat similar process the space requirements may be estimated for the auxiliary departments and purposes. Aisle space must be provided for, reserve storage space for work-in-process, space for timekeeper's and inspection cribs, for lockers, for washrooms, lunchrooms, and similar personnel equipment, for stores, tool, power, receiving and shipping, maintenance, office, and other departments.

There is now the task of arranging these processes and auxiliary departments into an articulated producing unit. Here again the assembly diagram is followed with modifications. Figure 26 gives a conventionalized assembly diagram for a simple assembly operation and a layout of the same machines, idealized to show the correct sequence from the standpoint of most economical flow of material. This layout would of course have to be modified to utilize space better, provide aisles, good lighting, power and other connections.

To conveniently work out the problems of securing a good layout of machinery it is customary to make drawings or blueprints to scale of the building to be used. It may be that the building is not constructed; in this case several tentative layouts of machinery may be tried out and a building worked out to fit the best general plan of arrangement. The floor plans which are to be used in layout will indicate windows, pillars, doorways, aisles if already fixed, safe floor load if heavy machines or materials are to be used, electrical, air, water, steam, and other connections, location of shafting and motors if installed, and all other facts of importance.

Templates are now cut to the size and shape of the floor space required for each machine or working space and for the various auxiliary spaces. These templates are then grouped, trying out various arrangements and, for each layout, following the movement of material through the machines by means of lines drawn, or of colored strings stretched from

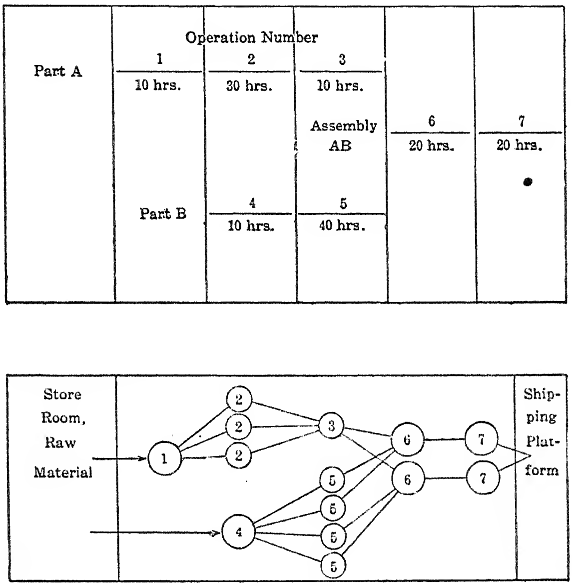


FIG. 26.

LAYOUT AS DERIVED FROM ASSEMBLY DIAGRAM.

pins at the machines. It is much easier to make the detailed adjustments necessary for a good layout with some concrete picture such as this before one. Here perhaps is a machine that uses long bar stock, and space must be found for a rack to hold the stock. Bulky tinwork is done at another machine, and the operator needs several times the usual allowance of space for handling and storing work in process. At this machine, perhaps, the operator must have the light at the left.

All these little details must be studied out by a man working with a carefully prepared layout drawing and templates, reference being had to the shop whenever a detail cannot be settled from the information given in template and scale drawing.

Analytic Process.—Three typical transformations may take place in the process of manufacture. A raw material may be broken down into a variety of products and by-products, as in the grinding of corn, the rolling of steel, or the destructive distillation of coal into coke, gas, tar and other by-products. These are essentially analytic industries. Figure 27 represents the breaking up of corn into starch, oil, etc., an illustration of an analytic industry. In the analytic industry there is a fan shaped flow diverging from the point of origin. Here there will be a single originating department supplying a group of final processing departments, as the killing rooms in the stock yards supply the raw material to meat dressing, canned meat and sausage, hide, tallow, bone, glue, fertilizer, curled hair, medicinal chemicals, oleomargarine and other departments.

Straight-Line Process.—A second typical transformation is the straight-line, in which the product passes through the various processes without substantial additions or subtractions of material. Illustrations of this type are the bleaching and finishing of cotton cloth, and the production of many simple unassembled articles such as milling cutters, drills, woodenware, etc. In many cases where the parts are small and are added one by one to an article growing toward completion, the layout of processes will be handled practically as in the straight-line industry. Thus in the tailoring of a man's coat, the material flows in a single main stream through the various processes. The ideal arrangement for the straight-line industry would be a long single-file arrangement of machines, the line being straight or looped as might be necessary to accommodate it to the building, while for the assembling industry we would expect to find a group of unit part depart-

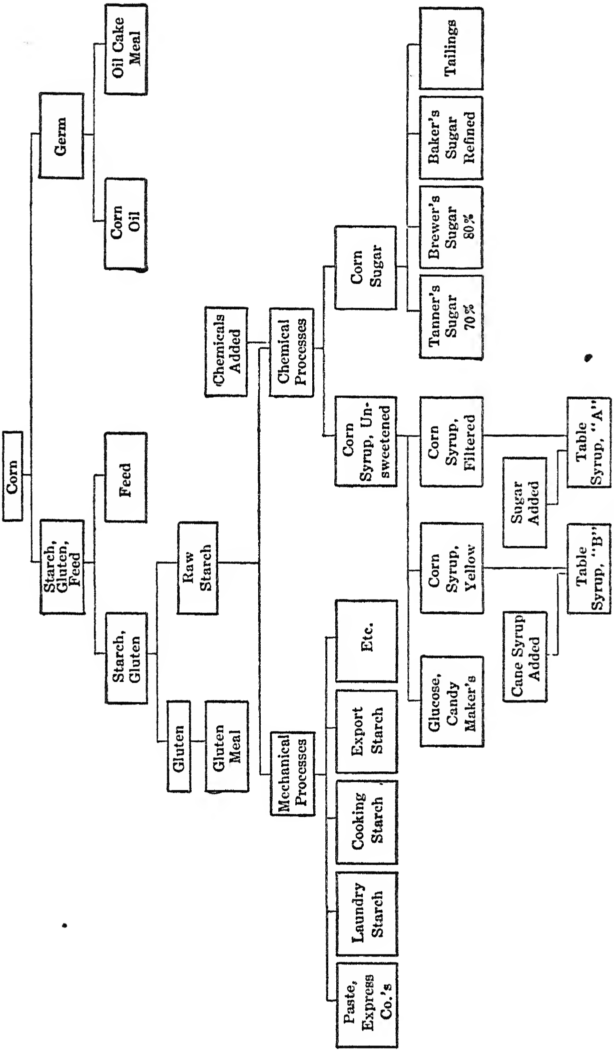


Fig. 27.

AN ANALYTIC INDUSTRY.

ments, conveying into sub-assembly departments, and these in turn into a single final assembly department.

Synthetic Processes.—The third typical transformation is that of the synthetic or assembling industry. The building of a machine, the making of an automobile, a watch, or a telephone, are of this type. Various chemical processes such as the manufacture of cement are of this type. Arrangement of departments and machinery will in this case be similar to the analytic process, but in reverse order.

Machinery.—Unless individual motor drive is used, a number of factors should be considered in making the layout. Power using machines must be grouped together so that they may be driven by as short a countershaft as practicable. Depending on conditions, the driving pulleys usually should be between ten and twenty feet apart, short belts being uneconomical because there is not enough weight of belt to prevent slippage unless the belt is stretched too tight, long belts uneconomical because of the flapping, liability of rubbing, of running off the pulley, etc. The pulley of the driven machine should not be directly under the driving pulley, since some sag is desirable to keep the belt tight on the pulleys. A double row of machines, back to back and with driving pulley centers six feet apart, connected to an overhead central shaft would represent a typical unit from the standpoint of belting.

It is usually best to place machines as close together as is practicable, and safe from the standpoint of the operator's liability to be caught by an adjacent machine. Close spacing saves handling of material, and overhead charges for shafting, floor space, heating, lighting, and other elements of expense.

Main aisles should be six to ten feet wide, to allow for trucking, etc., and side and individual aisles may be from three to six feet wide. In the case of large banks of machines of a kind, it is frequently a good plan to run a main aisle down the center the length of the building, with the machines in double banks, back-to-back, between side aisles

at right angles to the main aisle. Where machines using long bar stock (such as automatic lathes) are used they are usually set at a slight angle to the aisle, the belt running with a slight twist. In this way the projecting stock will overlap behind the various machines.

Flow of Materials.—As regards the general plan of flow of material it should flow in a straight line or loop, from one process to the next with the shortest practicable travel. Where several floors must be travelled there are two plans of arrangement. One is to have the material travel upward, being processed as it goes, to the top floor, where it may either be held for storage until shipment or may be dropped by elevator or chute to a finished goods storage and shipping space. The other plan is to lift the raw material to the top floor in bulk and move it downward through successive processes by gravity. The first plan is useful for heavy material, difficult to handle in bulk, which is cut up and perhaps reduced in weight in processing. It also permits the heavy machines to be placed on the ground floor, while the lighter finishing and assembly of products are done on the top floor, reducing vibration, lessening strain on the building and giving better light for the finer finishing processes. On the other hand, a substantial saving is made by the gravity handling of the second plan. The Western Electric Company telephone plant at Hawthorne is built on the up-flow plan, to manufacture switchboards (composed of slate, steel, lumber, wire, and miscellaneous parts) and telephone equipment. The main factory of Hart, Schaffner & Marx Company in Chicago is arranged on the other plan. Bolts of woolens are taken to the top story for shrinking and storage, and pass downwards for the subsequent cutting and tailoring processes.

Provision for Growth.—It is sometimes quite a problem, in the layout of the factory, to provide for possible growth, especially where the plant is on a limited city plot, surrounded by other buildings. One method is to build a larger factory than needed and to rent part of it temporarily. Another plan

is to make the foundations and walls heavy enough so that one or more stories may be added later. Thus Figure 28 shows the possible expansion steps of a U-shaped building adapted

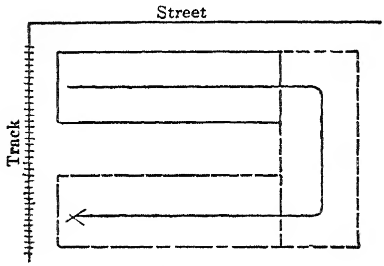


Fig. 28.
U-SHAPED BUILDING.

for a straight line of assembling process, the arrow showing course of movement of material.

Another plan, specially adapted to an assembly building,

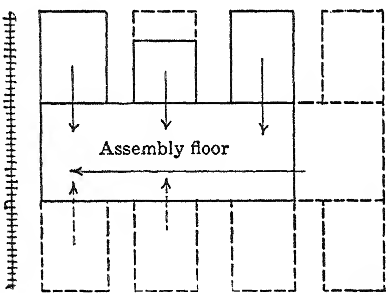


Fig. 29.
EXPANDING AN ASSEMBLY PLANT.

is to provide a central assembly building with unit part processes housed in buildings at right angles to it. Figure 29 shows an original building with possible extensions dotted. Figure 30 shows a very convenient modification of this type,

the unit operating buildings being at right angles to the assembly and office building at the end, and each unit wing being connected by cross ways at regular distances.

Usually an expansion of plant means a rearrangement of machinery, no matter how the building is planned. This moving of machinery may be minimized if consideration is given to the fact that expansion of product does not usually mean an equal expansion of all processes and departments. If the departments which will expand most are left in some way with "open ends" (as by being placed in a wing which may be

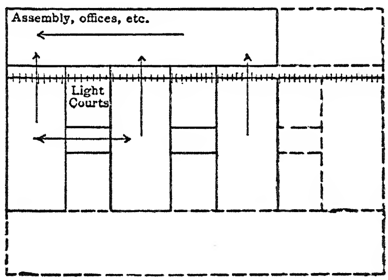


FIG. 30.

STANDARD UNIT FACTORY CONSTRUCTION.

added to, or in the end of the building) these departments may be expanded without disturbing the others materially.

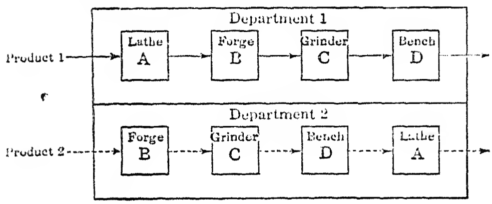
Where possible the power plant is usually placed in the center of any large plant group, since there is a loss both with steam and electric current in transporting over a distance.

Departmentalization.—Another point of importance in plant layout is the decision as to grouping machines into departments. Generally speaking we find conditions as to manufacture at some intermediate point between two extremes. One extreme is met when only one product is made, with no variations, and here we find that all the machines and equipment may be specialized and articulated so that the whole

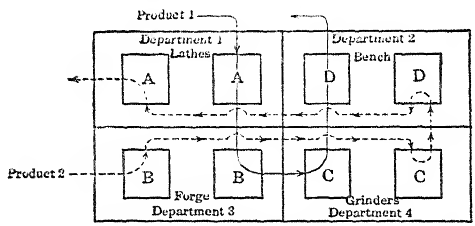
factory is just one big machine adapted as perfectly as possible to turning out the single product.

The other extreme is met where the variety of products is so large that practically no specialization is possible, but all the machinery must be selected for its capacity to perform a variety of operations, and the layout must be such that for each of the products it is possible to throw the machines into

A-Product Plan of Machine Departmentalization



B-Process of Functional Plan



Same products 1 and 2, same machines A, B, C, D, arranged (A) on product plan, (B) on process plan.

Fig. 31.

PROCESS AND PRODUCT MACHINE DEPARTMENTALIZATION.

a temporary combination which will be reasonably effective as regards movement of materials. In this second case, machine capacity figures will be based on the expected ratios of sale between the various products, and the best average layout will be selected, economy in the minor products being sacrificed if need be to effective movement of the major products.

Between these extremes there are many combinations, such as the repetitive factory with several products each made independently in a department, or the industry in which the general flow of work is standard but another set of tools must be used on each machine as another pattern of the product is made.

We find two general schemes of departmentalization. The first of these is the *product*, or divisional plan, in which all the machines for making one *product* are arranged in one group in accordance with the assembly diagram. This might mean that, for example, lathes were used at two or three points along the line.

The second plan of departmentalization is the *process*, or functional grouping, in which all machines performing one kind of *process* are brought together. Thus there would be a lathe department, a press department, and so on. Figure 31 illustrates diagramatically the machine layout and movement of material in each type.

Product Grouping.—It is evident that for the repetitive process, in which there is work of one kind in volume sufficient to keep the department busy, the travel of the product will be much shorter and more direct in the product grouping. Where there is a variety of products each with a different sequence of operations this does not matter so much, since what might be a good layout for product 1 might be very bad for product 2.

The product grouping will also simplify departmental accounting, since the product remains in one department from start to finish. Responsibility can also be fixed definitely for the cost of any product, and for its prompt delivery. Also department "1" would not be affected by a breakdown in department "2," and we would not find the condition sometimes occurring in a functional organization, where the whole organization is paralyzed by the breakdown of one department.

Process Grouping.—On the other hand, the process or functional grouping would be advantageous in that by having all

work of one kind, such as the lathe work, done in one department uniform standards of workmanship are ensured. The foreman, also, could be a lathe expert instead of having to scatter his activities over several fundamentally different processes. Special auxiliary equipment and workmen, such as machine setters, could also be provided conveniently for each department. And most important of all, only enough lathes or presses or milling machines would have to be provided to take care of the total demand of the factory, instead of having lathes scattered at various processes, where they might stand idle two thirds of the time. This reduction of equipment requirements by improved *load factor* is probably the strongest argument for the process plan.

The process and product plan fit, respectively, the repetitive and the variety types of industry, since the concentration of equipment on one volume product in the first case makes saving of travel important and eliminates the question of load factor by keeping all machines busy simultaneously, while in the second case a universal solution of the travel question for all products is usually impossible anyway, while the irregularity of use makes the load factor of machines important.

As the variety industry becomes very large, the question of travel or movement of material necessary with a process grouping becomes a serious one. With growth, however, the quantity of each line made tends to increase, so that it is usually possible in such a case to regroup the plant into several primary product divisions, each of which may in turn be subdivided either on a process or product plan. This was done by the Westinghouse Electric & Manufacturing Company, when the growth of their electrical apparatus business had made the earlier primary functional grouping an unwieldy one.

Equipment Administration.—Usually in considering the purchase of new and improved equipment, looking at it from the question of investment, we must ask, Is the saving in unit operating cost with the new machine sufficient to balance

the first cost and interest charges of the new machine, during the period of its probable life, and still show a profit? If the machines or equipment are likely to be used on one order only, this means that the entire cost must be absorbed on the one order. The cost of special equipment such as dies, printing plates, etc., is usually charged direct to the order or written off as current expense.

An inventory is usually kept of all equipment by means of a loose leaf or card record, listing each machine with date of purchase, name of seller, price, normal life and similar data. In the case of permanent equipment such as machinery, the total value as shown by these records forms a part of the fixed assets of the company. Each year a certain amount is deducted from the value of each machine, proportional to the fraction of the total expected life of the machine which has been consumed during the year. Permanent additions or repairs prolonging the expected life of the asset may be added to its valuation, but the repairs incidental to operation are usually considered as current expense, adding nothing to the assets of the company.

Operating economy requires that all machines and transmission equipment shall be periodically gone over, belts adjusted, shaftings aligned and bearings oiled. Supervision is also required to see that compressed air is not wasted, lights left burning, idle machines left running and steam, air and water leakages neglected. A maintenance or millwright or plant engineering department is usually part of the organization, responsible for this work, (1) for construction, installation and changes of equipment (2) on demand, for emergency repairs, (3) for regular inspection of belts and shafting, replacement of burnt out light globes, tightening up of pipe connections, etc.

Tools.—In addition to the machines and power equipment referred to before, a number of other classes of equipment are found in the average factory. These may include the following: (1) *Hand tools* such as hand hack saws, vises,

files, etc., really small independent machines. Included in this class would be most of the small portable air drills, riveting hammers, etc. (2) *Machine tools,* such as punches and dies for the punch press, drills, lathe tools, milling cutters, etc. Each of these is used as a working part of a machine, made separate so as to be removable for grinding, adjustment, or interchangeability. (3) *Holding devices,* or tool-guiding tools, such as the jig (a box or other device into which an irregularly shaped casting may be clamped for convenient centering of drilled holes or for other operations), the dog (a special lathe clamp), the chuck (a revolving or fixed vise whose jaws grip the work), and various clamps and special holding fixtures. (4) *Measuring devices,* such as the micrometer, calipers, scale, and a great variety of gauges, etc. This list is illustrative rather than inclusive, since many special tools will be found in addition to the prominent types mentioned.

The purchase of this class of equipment is subject to the same general considerations as to probable saving and probable period of useful activity that obtain in the case of larger equipment. Thus if the tool is for a temporary use, it will be requisitioned in an ordinary carbon steel, while if it is to be used many times, high speed steel will be used. For the small job a makeshift holding jig or die will be made to serve, while considerable cost may profitably be put into the refinement of design of a more permanent tool. In the case of the numerous special tools and fixtures used in the average factory, the design of these tools should go along with the engineering design and process layout of the product. In industries having much of this class of work a special tool-making department usually exists, to carry out the orders or help work out the problems of the tool designing engineer.

The storage and handling of tools follow lines very similar to those used in storekeeping of materials. The various standard sizes and kinds of tools should be identified by some simple classified symbol system. (Symbol systems are described more in detail in Chapter X.) A drawer, shelf, peg,

or some kind of a place is provided in the toolroom for every tool used, usually following the same classification used in identifying the tool. Tools are issued to the workmen at the tool room window, the workman giving either a brass tool check or a requisition in exchange for the tool. This check is put in the tool's place and remains there until the return of the tool. Usually the man is supplied with a number of these brass checks, which must all be accounted for before he leaves and is paid off.

Some tools are in constant use at some one machine. It would be a waste of time to check these in, every time, and in such cases the man signs a requisition for a specified tool which is left permanently at his machine. Generally speaking, however, all tools should be at the tool crib when not in use. Workmen like to fit themselves out with complete outfits and little hoards of tools, which they "might need some day," and if each man is thus outfitted a very large amount is tied up in tools which are seldom used and in fact may be forgotten by their possessor. When a central toolroom was installed by one large company, something over $100,000 worth of tools were found, of whose possession the company was totally unaware. It is another case of the improved load factor obtained by centralizing. Further advantage may be taken of this idea in the large plant by operating a central toolroom, which carries reserve stocks of tools and special expensive tools used only occasionally, the tool crib requisitioning the central department as necessary.

The tool department should also be charged with the duty of inspecting each tool on its return, fixing the responsibility for breakage, and of sorting out and conditioning tools which need sharpening, grinding, etc.

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CHAPTER VIII

TIME AND MOTION STUDY

In Chapter V the method was described by which, as one of the functions of design, the process of manufacture of an article was planned and the operations laid out. In the typical case the route clerk is, however, primarily concerned more with specifying the general order and method of manufacture than with the precise details of how each operation is to be performed. This is especially true where his duties, as in the special order and lot repetitive business, are a routine part of production. In the flow repetitive factory he stands in a more detached position and may include more specific details in his studies. However, the study of the operation is commonly separated from the general planning of operations, and is given over to a time study man whose special function is the study of the operation with the twofold purpose, first of improving it either in cost or in results or both, and secondly of ascertaining and establishing as a standard the time required for the performance of the operation under normal factory conditions. This time is of importance to the schedule clerk, in his apportionment of machine capacity, and to the rate setter in establishing the rate to be paid the workman for doing the job.

In any factory in which such studies have not been undertaken there is apt to result a surprising showing of opportunities for improvement. Mental inertia and laziness, on the part of management even more than men, an inadequate grasp of the production problem as a whole, a dislike and often suspicion of change, explain many of the inefficiencies. The fact that operating officials are absorbed in routine and that

no staff man is provided specifically to deal with questions of method also accounts for such conditions as those found in one factory where bar stock, long, heavy and awkward to handle, was taken from a basement up a narrow stairway to a second floor, where it was cut up, then back to the first floor, and finally after processing to the third floor. That was the way which had first suggested itself to the overworked foreman and it had never been changed.

Study of Auxiliary Functions.—The first step in the study of an operation with a view to improvement should normally be a survey of the auxiliary and supply functions upon which the operation depends. An effort to save a few seconds on the process itself does not appear as reasonable to a workman who is accustomed to be held up for minutes or hours by irregularities in supply of material or lack of proper tools. Also, a new man doing this work is undertaking a task involving intimately the habits and feelings of the workman and requiring a considerable degree of diplomacy, and the study and showing of results in such non-controversial fields as storage, tool supply, etc., gives him a chance to make acquaintances and disarm suspicion, and to avoid hasty judgments, in subsequent rate-setting and operation studies.

He will therefore concern himself first (assuming that he must start from the beginning) with a study of material supply questions such as the proper anticipation of wants by the purchasing department, the use of stock records with maximum and minimum limits to prevent unexpected shortages, the identification and location of parts so that they do not get lost in the storerooms, the system of requisition and delivery of material to the workmen, and similar questions. He will see that material received from vendors is of proper quality and suitably inspected so as to ensure uniformity and to avoid delays through attempts, for example, to assemble castings which have not been accurately molded. He will see that tools are checked up and provided for before the operation starts, that necessary drawings are sent out with the work

order, that tools are inspected and sent out sharpened and ready for work, that patterns, gages, supplies, and all the numerous auxiliaries are on hand when needed and in condition for work. He will see that there is at least enough scheduling done so that before a man finishes one job there is another ready for him, so that the foreman does not have to "make work" or invent a job until he can hunt one up for the man.

The time study man will also go over the machinery, and will see that belts are properly adjusted, at the right tension and running true on the pulley. He will see that shafting is aligned, that machine foundations are heavy enough to prevent vibration. He will test the running speed of machines, seeing that the machine is run at its full economical working speed and will inspect the machine itself for wear or maladjustment.

General working conditions as to hours of work, temperature, ventilation, proper lighting, drinking water, removal of dust and protection of operator from dangerous machinery should also be investigated and corrected if necessary as a preliminary to more intensive work.

General Study of the Process.—Next will come the study of the process itself. First there must be a degree of standardization of the article and of the general process of manufacture. This may involve the design of the article. Often there are no specifications or drawings for it, and it may vary and change in details from time to time. One man may put in a brace, another may leave it out. Size of wire may be changed, parts may be attached sometimes by riveting or sometimes by bolting, length, finish, weights, all may vary if left to the discretion of one workman or a succession of men. Process study therefore must often start with a standardization of the article itself. The making of bills of materials, of assembly diagrams or lists and of route sheets, embodies this step and should precede any work in rate setting. Next comes a critical analysis of processes. The

part may be entirely unnecessary. "Double-deck" bedsprings used to be made by first assembling one layer of springs and then building a second separate layer on top of the first. Someone conceived the idea of substituting a deep continuous coil anchored at its middle to adjoining coils, and by doing so completely eliminated several processes.

There may be a choice of processes. Modern methods of producing accurately finished die castings have made it possible in many cases to eliminate or reduce the costly machinery needed to bring the rougher castings, made in sand, to proper dimensions and finish. The use of molded Bakelite has similarly displaced many uses of hard rubber, amber, metal, etc., at a decrease in cost. Transfer or decalcomania labels may sometimes take the place of metal labels which had to be riveted, requiring holes to be bored or punched into the article. Drop forgings or steel castings may take the place of parts machined from solid stock. Examples might be multiplied of large saving initiated by challenging the process itself. Naturally this is not the work of the time study men alone. The engineering department, an alert purchasing department constantly having new things presented to it by salesmen, the manager, the salesmen, and many others contribute. But the time study man also will challenge the process itself before studying its details.

The study of supply and control systems, the analysis and standardization of the product, and the study of general process methods is a matter of months or a year or more where it must be done from the beginning. Prior to its completion there is little object in exhaustive motion studies.

Time-Study Methods.—Accepting the general article and type of process as standard, the next step will be the critical study of the process itself. In this study the method advocated by Frederick W. Taylor and his associates, and generally adopted, is the analysis of the operation as a whole into a cycle or series of elements. Various methods and combinations or variations of these elements may then be tried and com-

pared. The observer first watches the performance of the operation, noting down on a data sheet the list of elements composing the operation. The cycle is then followed through, several or many times, and the time for each element recorded by the use of a stop watch or other timing device. A stop watch generally used has the large dial divided into hundredths of a minute, while the smaller or second dial records whole minutes up to thirty. It is mounted on the upper right hand corner of a clip board which also holds the data sheet, so that both may be conveniently held in one hand while the operator follows the work. In timing it is convenient to select some characteristic click or sound or distinct motion as the separation point for an element, to facilitate recording. It is sometimes necessary to follow an operation continuously for a long period, with frequent readings involving a considerable strain on the observer's attention.

The stop watch is usually snapped back to zero by pressing the stem and is released at the start of the operation, and as the end of each element passes, the time is recorded, the watch running continuously. Unit times are subsequently obtained by subtraction. To facilitate recording where the reading is to be repeated many times and only small variations in cycle may be expected, each operation may be given a key number, including a key number for idle time and interruption. The key number will then be used instead of trying to write operations out in longhand. Careful notes should be made of the conditions of the test—operator's name, skill, rate of pay, machine and tools, a diagram showing the set-up and position of job, kind of material, notes as to special conditions, interruptions, etc., so that no essential fact is left to the memory of the operator. The data form used should provide spaces for all needed facts. A typical one, with study, is shown in Figure 32.

Computing Standard Times.—After the completion of a series of observations the unit times will be obtained by subtraction of the continuous readings, and times for the same

Observation Sheet	Part Number
Observer's Name	Date
Operation – (Getting out an order of steel angles for shipment to customer, steel warehouse.)	
Machine – (Overhead travelling crane no.________)	
Workman's Name and Qualifications – (Crane operator # — rate – per hr.)	
(Floorman # — rate – per hr.)	
Notes	

No.	Operation (Floorman)	Operation (Craneman)	Continuous	Individual	Continuous	Individual	Continuous	Individual	Minimum Time (Minutes)
1	Reads stock ticket	Raises hoist to	.30	.30	.35	.35	.25	.25	.25
		working level							
2	Goes to proper section of span (4 spans)		.75	.45	.80	.45	.80	.55	.45
3	Climbs to top of stock	Lowers hoist	1.20	.45	1.25	.45	1.35	.55	.45
	pile								
4	Places hook on end of stock	Idle	1.30	.10	1.37	.12	1.45	.10	.10
5	Idle	Raises hoist							
6	Places block under stock	Idle	1.38	.08	1.45	.08	1.55	.10	.08
7	Idle	Lowers hoist	1.48	.10	1.55	.10	1.66	.11	.10
8	Places chain around stock	Idle	1.57	.09	1.65	.10	1.76	.10	.09
9	Idle	Raises loaded	1.77	.20	1.85	.20	1.97	.21	.20
		hoist, lowers							
		empty hoist							
10	Places chain around stock	Idle	1.97	.20	2.07	.22	2.20	.23	.20
11	Climbs down from pile	Raises both hoists	2.29	.32	2.42	.35	2.56	.36	.32
		level and to clear pile							
12	Goes to car to be loaded	Goes to car to be	2.69	.40	2.82	.40	3.05	.49	.40
	4 spans	loaded							
13	Idle	Lowers load into car	3.09	.40	3.20	.38	3.35	.30	.30
14	Unfastens chain of	Idle	3.19	.10	3.35	.15	3.46	.11	.10
	one hoist								
15	Unfastens other hoist	Idle	3.28	.09	3.50	.15	3.56	.10	.09
				Minimum time					3.18
				Percentage allowed – 10					.32
				Standard time					3.50

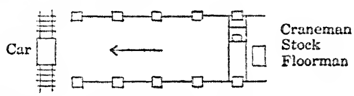

FIG. 32.

TIME STUDY OF TWO WORKMEN.

or alternative elements compared. Improved combinations may be worked out and tried experimentally, to see, for example, if the elimination of an apparently useless motion can be made without increasing the time for other elements.

In determining on the standard time the method used by Taylor was to select from the various observed times an ideal cycle composed of the shortest time for each element. Judgment would have to be used in eliminating abnormal times or times shortened at the expense of other operations. To this ideal or minimum time was added a percentage determined by experience to cover the delays necessarily incidental to the operation, for rest, interruptions, etc. Typical percentages are an allowance of 10 per cent on machine time (machine operating while operator merely watches and regulates it)

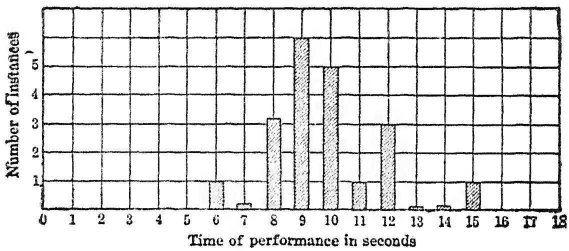

FIG. 33.

DISTRIBUTION OF UNIT TIMES.

and 30 per cent or more on handling time (operator actively setting up, handling material, etc.)

Where the object of the time study is not to discover possibilities for improvement but to determine accurately the time normally taken by the operator, an alternative method of analysis would be to group the times taken for each element according to frequency of occurrence. Thus operation number six might have been done once in six seconds, three times in eight, six times in nine, five times in ten seconds, once in eleven, three times in twelve, once in fifteen seconds. If the operation is new to the operator and habits have not been formed there will be a tendency for the times to vary thus, but if the operation is a habitual one the range of times will be very narrow, and a characteristic or modal time of perform-

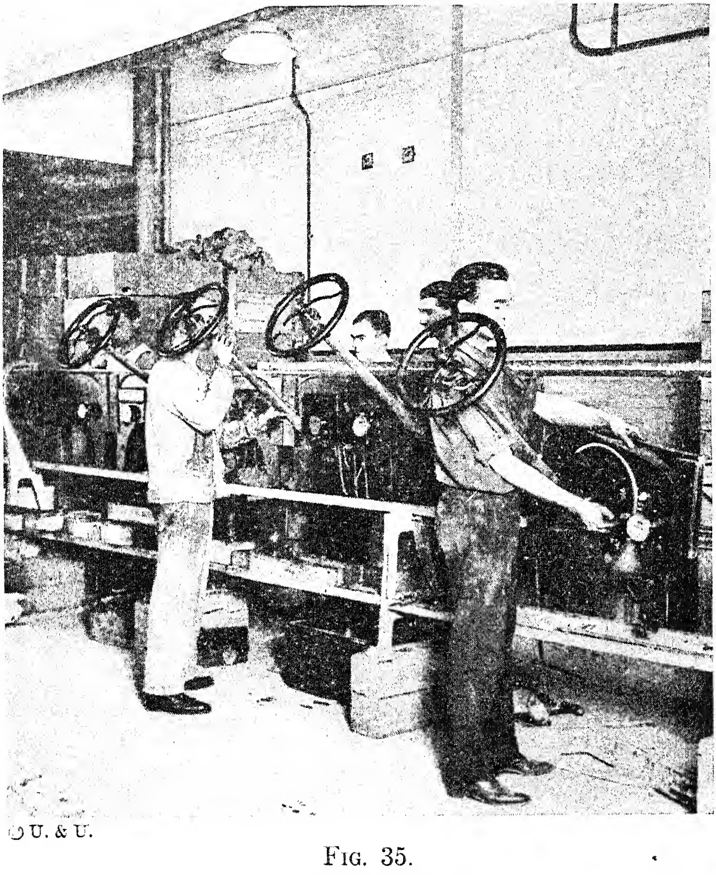

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FIG. 35.

A PROGRESSIVE ASSEMBLY.

ance (which may or may not coincide with the average time) may be selected. These times may be charted as in Figure 33, giving the characteristic bell-shaped frequency curve of statistics, and indicating clearly the normal or modal performance and the range of variation.

Skilled or habitual operations in which the work itself is unvarying tend to be done in times which are strikingly uniform. A check on the skill of the operator and the reliability of the reading may be made by using as a deviation coefficient the average percentage of deviation, plus or minus, from the modal or normal time.

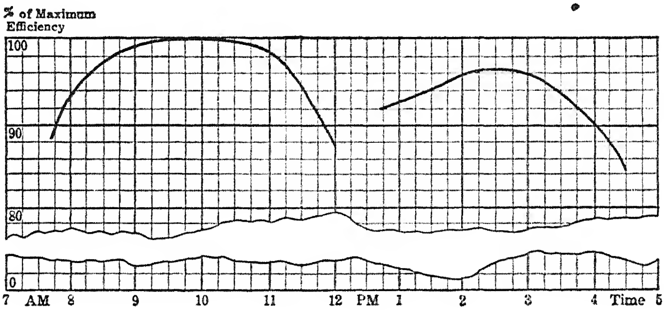

Fig. 34.

VARIATION OF OUTPUT WITH TIME OF DAY. FATIGUE CURVE.

Corrections may be made for varying output at various times of the day by constructing a curve showing the average performance for each hour of the day, in terms of a percentage of the maximum output. Such a curve, shown in Figure 34, which was the ten day average of a forge shop worker, shows clearly the warming-up period during which habits are being re-formed and attention concentrated for the day, the period of maximum morning efficiency, the rapid drop both morning and afternoon as quitting time approaches, and the slower warming up and lower total efficiency of the afternoon period.

Other devices are also used to secure records of operation times, such as the Productograph, which records the strokes of a press or revolution of a machine on a tape moved at a constant speed or time-scale, by clockwork. Counters may also be attached to a machine, or tests be made by measuring time and output for a day or other period. Motor trucks may have meters attached which show running time and idle time. Frank B. Gilbreth has introduced two interesting methods for very exact and minute timing. In his "chronocyclegraph" he attaches a miniature electric light to the moving hand of the operator. This light is periodically rapidly interrupted by a timing device. A time exposure is made of the operation by a stereoscopic camera, the moving, interrupted light showing the path of the motion as a series of dots whose distance apart indicates time taken. Gilbreth has also simultaneously photographed on a moving picture film the operation to be studied and the dial and rapidly moving hand of a clock, giving a film record which may subsequently be reproduced for instruction purposes or dissected, picture by picture, for motion analysis. These two methods have not been generally adopted commercially since the usual purposes may be served sufficiently by more approximate methods, but they present splendid possibilities as tools for research.

As records are accumulated it is frequently possible to collect and classify times of the same nature and often to reduce the time required for any operation of the particular type to a formula. Taylor in his "Shop Management" shows how a formula may be derived for the time in loading and wheeling sand. Similarly in supplying paper stock to printing presses it was found that the time of handling and placing the stock on the feed bed of the presses was constant up to a certain size of paper and increased at an accelerating rate with larger sizes. By plotting readings on four or five sizes from small to large as a curve on coordinate paper, it was possible to interpolate with sufficient accuracy the time for intermediate sizes. Similarly in the unloading operation

shown in Figure 32, it was found by studying various lengths of haul that a time of ten minutes per span was required for the floorman to walk to and from the stockpile. As an illustration, take the study given in Figure 32. This operation consists of a number of elements which are constant, no matter what distance the steel must be carried by the crane, and of a variable operation, number 12—"goes to car to be loaded"—the time of which, for four spans, is 0.40 minutes. Based on other studies, we might determine that 0.10 minutes per span was the correct time for the element of walking and moving the crane. Our time formula would then be: (Total operation time) = 3.10 minutes + (.10 minutes) × (number of spans). If the formula contained another variable dependent on the weight, say, of the material to be chained and loaded, this could be analyzed in the same way, as a constant time independent of the weight and a variable time proportional to the weight according to some ratio. This element also could then be included in the formula.

As data are thus collected and put in systematic form, studies become increasingly accurate and consistent, and rates may be set for piece work with reasonable assurance of correctness for many jobs on which the size of the run would not justify individual time studies, simply by analyzing the job into its elements and combining the times previously taken for similar elements as recorded in the record of standard operation times.

Getting back from the process of recording operation times to the constructive analysis and improvement of the operation, a number of principles and suggestions of fairly general application may be noted. Each case of course is apt to involve special elements arising from the nature of the process.

Operation Elements.—Gilbreth divides the possible gamut of motions in an operation cycle into stages such as:

1. *Reach* for material (as to a supply table at a drill press).
2. *Grasp* material.
3. *Move* material to point of operation (on drill press table).

4. *Pre-position* material (in jig, or beneath drill, etc.).

5. *Operate tool* (bring revolving drill down and drill through material).

6. *Remove tool* (throw up drill head).

7. *Move to "reach"* position.

In the stage of moving work to the machine, a number of rules should be observed. (1) Extended reaching should be avoided. Workers should be seated if possible, and at a convenient height in relation to the point of operation.

(2) The operator should be able to grasp the part in a position correct for prepositioning, without looking or fumbling. Various devices aid in this object, such as putting parts into a feeding device which lets one part at a time roll down to a position convenient for grasping, or having parts come to the operation in uniform packets, etc.

(3) The operator should lay down the tool (if used) and the work in the same position each time. Many studies of desk efficiency are based on this idea of having definite places for each implement or kind of stationery and forming the habit of reaching for an article and putting it back always in the same place.

(4) On repeated or continuous work the material may well be brought before the operator by a conveyor, moving at such speed that the operation may comfortably be completed before the next part passes. This is the principle used in the famous progressive assembly of the Ford automobile. Frequently, as in labeling cans, packing biscuit, etc., a group collectively performs one operation, the material being moved slowly past the group on a conveyor or belt, the first operator taking what she can manage, and the work being so timed that the last operator can clear the belt. Sometimes the same result may be secured on smaller material by having work pass from hand to hand at a long bench, the finished pile for operation No. 1 being put in position for the start of operation No. 2, and so on.

(5) Balanced motion of the hands is preferable to unilateral motion. Thus Gilbreth gives the example of an operation of folding handkerchiefs. The girl operator had previously reached to one side for a handkerchief and accompanying paper, folded them, and placed them on the other side. The paper was placed on one side, the handkerchiefs on the other, the two were simultaneously brought together by the operator, one in each hand, folded, and placed in a pile in front of her.

Functionalizing the Job.—A second general possibility in the study of the operation is the question of subdivision of functions. Generally speaking, breaking an operation into smaller separate functions results in economy (1) because skilled and unskilled work may be separated and the latter performed by cheaper labor, (2) because workmen acquire greater speed on the simple element than on the more complex one. On the other hand, functionalization means greater problems in coordination—keeping operations in step—and means less flexibility in meeting decreased load, since the whole group must work, no matter how small the output.

Henry Ford thus briefly describes his company's assembly methods ("My Life and Work," *McClure's,* July, 1922, Ford and Crowther).

The first step in assembly came when we began taking the work to the men instead of the men to the work. We now have two general principles in all operations—that a man shall never have to take more than one step, if possibly it can be avoided, and that no man need ever stoop over.

The principles of assembly are these:

1. Place the tools and the man in the sequence of the operation so that each component part shall travel the least possible distance while in the process of finishing.

2. Use work slides or some other form of carrier so that when a workman completes his operation, he drops the part always in the same place—which place must always be the most convenient place to his hand—and if possible have gravity carry the part to the next workman for his operation.

3. Use sliding assembling lines by which the parts to be assembled are delivered at convenient distances.

The net result of the application of these principles is the reduction of the necessity for thought on the part of the worker

and the reduction of his movements to a minimum. He does as nearly as possible only one thing with only one movement.

There is considerable opportunity for the exercise of ingenuity in the design of small tools for holding, measuring, etc. Templates or stencils may be designed for laying out the work quickly. An interesting machine in the Ambridge Shops of the American Bridge Company saves many hours of expensive labor in laying out for punching the holes in the big plates of structural steel which are assembled into girders. A series of punches are set in separately movable heads in a row across the table of the machine, so that by means of a lever control several holes may be punched simultaneously, one inch, two inches, etc., from the edge of the plate. The plate itself is secured to a long travelling bed, which by means of a series of notched stops may be advanced any required number of inches or feet. The stops are set in advance, for each cross row of holes. The operator, working from a list before him, rapidly advances the plate stop by stop, at each stop bringing down the proper set of punches, as shown by the key list.

The common drilling jig is an illustration of a study of this sort which has become standard practice. The work is clamped in the jig in a fixed position and drills are brought down one at a time or in multiple, and, guided by hardened bushings in the jig, perforate the metal at exactly the proper point, without any work in laying out the piece or centering the drill. On quantity production twenty or more holes may be bored from four sides simultaneously by such devices.

Improving Tools.—A third general field is a study of the machinery and auxiliary devices. Essentially, the decision as to whether to put in a new machine or not is a question of whether the operating economy will absorb the first cost and fixed charges of the machine within its useful life, which may be very short if the process is changed or abandoned later.

Figure 35 illustrates a small group assembling the instrument board of an automobile. A study of the photograph will show the successive additions of steering wheel column and of the various instruments, and will emphasize the degree of detail to which it is necessary to carry motion studies of progressive assembly layouts, in order to adjust the amount of work at each position so that all will be completed simultaneously. Other points requiring study would be the designing of an effective work slide or power conveyor, the designing of suitable tools and of tool boxes or tool holders which would ensure the man's laying down and taking up the tool in an automatic and habitual manner. A characteristic feature of automobile factories is the very extensive use in assembly gangs of the plan of suspending tools, with a counterweight or light spring where necessary, so that the man can let go of his tool the moment he is through with it, and grasp it again without bending over for it. Another problem, not as specifically shown in this picture, is the convenient supplying of materials to the assemblers. Sometimes this material is brought in trays or tote boxes by attendants, sometimes, for large parts, a chute feeds direct to the position from a storeroom, and is supplied at the proper rate of speed by an attendant. Often the supply point is itself the ending of a smaller or sub-assembly, so arranged that the last man in the sub-assembly puts his piece down ready for a particular position in the next superior assembly line. Storage of work in process may be almost completely eliminated by this plan, thus substantially reducing inventories.

Habits of Work.—Frequently improvement in output in a factory is contingent not so much on detailed study of the operation as upon the improvement of habits of work and spirit of the organization as a whole. H. L. Gantt in his book "Work, Wages, and Profits," Chapters VIII and IX, has given an account that deserves to stand as a classic of just how this was accomplished in a cloth weaving mill. It involved the careful, painstaking analysis of the operation, improvement of

surrounding conditions (as supply of material and maintenance of the looms) and determination of a standard method and time for the operation. Then came the patient training of one weaver, Samtak, in the new method as a future foreman, and the gradual instruction and change of spirit of the remaining operators.

Sometimes where the factory force is home grown, so to speak, and standards of output are not satisfactory, it is advisable to bring in a few of the best skilled men available from other cities or shops as instructors and pace makers. These men work side by side with the crew in training, and the local men acquire speed and better methods by imitation. If handled in a tactful and aboveboard fashion no offense need be given to the local men.

The instruction of the men in the improved methods is a subject of serious importance, if the full benefit of intensive motion study is to be obtained. In the vestibule school, so called, the new operator, or old operator learning new methods, is placed in a separate department, where, under the detailed guidance of a trained instructor, exactly the right work habits are formed, one operation being fully mastered before another is learned. Operators may be trained in this way in periods ranging from one or two days for single simple operations to three months for more complex duties. The object of the vestibule school is the accurate teaching of simple work habits.

Job Analysis.—The adaptation of the worker to his job has recently formed the subject of investigations, and the method of job analysis has been developed. This information, while primarily of interest to the employment department in selecting men for particular jobs, may properly be gathered by or in collaboration with the time study man, being essentially part of the design function. In the job analysis a record is made of the conditions of the work, as dusty, hot, monotonous, much or no overtime, temporary, and other special conditions and also of the type of worker required—trade skill, intelligence, physical strength, special physical qualities, mental

1. Name of job .... Number ....
2. Description, showing relation to the process as a whole .... Department ......
3. Maximum number of men employed at job .... Date ....
4. Hours and shift .... Taken by ....
5. Wages, paid by day, piece, bonus, etc., starting and high limits ....
6. Time required to learn operation ....
7. Type of work.
   (a) Posture—sitting, standing, stooping, walking, climbing ....
   (b) Motion—quick, slow, steady or occasional..........
   (c) Small dimension hand-work, large dimension machine work ....
   (d) Heavy or light work ....
8. Physical requirements.
   (a) Size of men, tall, short, heavy, light, muscular or not ....
   (b) Eye-sight and hearing ....
   (c) Age and sex ....
9. Nationality preferred ....
10. Mental characteristics.
    (a) Education ....
    (b) Type of mind: (Check.)

1. Mental	Manual	5. Deliberate	Impulsive
2. Settled	Roving	6. Initiative	Not needed
3. Indoor man	Outdoor man	7. Directive	Dependent
4. Adaptable personality	Self centered	8. Large dimension worker	Small dimension worker

FIG. 36.

TYPICAL TOPICS COVERED IN A JOB ANALYSIS RECORD.

alertness, restless or settled type of mind, age, sex, and other qualifications considered desirable. Chances for promotion, rate of pay, and all other pertinent facts are gathered into this record, which is then filed by the employment department and used in subsequent hiring. An outline of one job analysis record used is shown in Figure 36.

Operation analysis in a comprehensive sense thus involves the study of the job in its complete setting. Indeed, from one point of view the whole productive organization exists in order that material may be smoothly and effectively brought to and carried through the processes of operation, and no study of operation efficiency is complete which does not audit and where needed revise all the auxiliary functions of design of product and tools, supply and movement of materials and auxiliaries, and control and planning of operations. Workmen usually try to work effectively unless discouraged by poor management. The beam of managerial incompetence should be removed before attention is given to the mote in the eye of the workman.

Labor and Time Study.—A great controversy arose at the time of the announcement of Mr. Taylor's methods, as to the social justice and desirability of time study. It was claimed by labor leaders that motion study was unjust to labor because:

1. It robbed the workingman of his monopoly of trade skill and lowered the skill requirements of the job.

2. By substituting numerous individual agreements, incidental to the making of separate rates from time to time, for the single trade agreement of the collective bargain, it weakened labor's position in bargaining.

3. Acting on the theory that "there is not enough work to go round" the man who increased his output was taking bread from the mouths of fellow workers. This argument is in the long run fallacious, but is very humanly natural.

4. Labor also claimed, and correctly from the point of view of economic theory, that the ultimate profits of an increased output went not to them, but in the main to the public,

since competition tended to force down the higher wage at first earned.

There was also undoubtedly an instinctive revolt arising from the feeling of being put under the microscope, so to speak, by the impersonal and "inhuman" time study man. Much damage was done by misguided and untrained enthusiasts who presented time study as a panacea for all industrial ills.

As it is found today, time study is a matter-of-course part of the management of most large companies having frequent occasion to set piece rates. The rate setter, it is true, has a somewhat trying job, as the setting of the piece price becomes the focal point for dissatisfaction with wages and for attempts to bargain by force or otherwise for a better wage. But if he is an intelligent, fair, and firm man who performs his function impartially he comes to be respected by the men.

One difficulty with the usual plan of rate setting is the fact that the company usually undertakes to guarantee the rate, and if an error is made, is apt to find itself in a false position from which it is difficult to recede without breach of faith. In a number of cases, including the Westinghouse Electric and Manufacturing Company and the National Associated Men's Clothing Manufacturers, the final setting of rates was placed in the hands of a joint board of employers and employees or of an impartial rate setter paid jointly by both sides. Or either side is permitted to employ time study men to check a rate about which complaint is made.

As mentioned, time study and rate setting should normally be the last things undertaken in any improvement of shop conditions. Where management is intelligent and alert and a good spirit exists among the men very good results are frequently obtained with no motion study of the conventional type except for rate setting purposes. Adequate detailed motion study and analysis of product is a considerable expense, but when judiciously applied it has the possibility of effecting large savings.

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CHAPTER IX

PURCHASING

THE departments directly concerned with the supply of materials are the purchasing, receiving, and stores departments. In the organization chart, if the work of the purchasing agent is important to the success of the firm he is often shown reporting to the general manager, on a par with the works manager, or sometimes of vice-presidential rank. Sometimes the important buying is done by the chief executive, and the man who bears the title of purchasing agent is of subordinate rank and responsible only for the less important purchases. The work of purchasing divides itself into speculative and routine buying, to use Farquhar's terms, and the two functions are often separated.

The receiving department may be under the purchasing department, or it may report to the works manager or superintendent. Sometimes the receiving and shipping departments are combined, in smaller plants, since the work is similar and both are located at shipping door or track. The stores department may report independently to the general manager. More usually it reports to the works manager, or is treated as a subdivision of the production and planning department.

Purchasing Routine.—The purchasing agent may be in charge of the whole question of policy as to buying, or he may buy only on requisitions, which for productive materials originate normally in the stores department under the control of the stock limits. In any case a careful knowledge of market and supply conditions is regarded as part of the duty of the purchasing agent. He is usually a responsible executive, whose judgment and initiative count heavily in profits.

A case comes to mind of a large company which showed a profit for the year of two hundred fifty thousand dollars, offset by a loss in a single contract placed at top prices, of two hundred thousand dollars.

The following is the organization and routine of a large purchasing department. The department consisted of (1) purchasing agent, assistant and secretary; (2) a group of six buyers with stenographers, each buyer handling a class of material, one for steel, one for lumber, etc.; (3) a clerical department which (a) wrote orders on information furnished by the buyer, (b) acted as mailing department and (c) as filing department; (4) a group of follow-up men, who by telephone, correspondence, or personal visit followed up orders to ensure delivery as per promised date; (5) an invoice checking department. To purchase an item, it was necessary that a requisition be sent by the department needing the item to the purchasing agent. He approved it, checking it against the department's budget or expenditure allowance, and turned it over to a buyer, who by telephone or mail secured prices and specifications if necessary, or placed the order direct if with a customary supply source. A purchase order (Figure 37) numbered serially was then written, with copies for the vendor, for the purchasing department, for the reference file (filed numerically), for the follow-up-man (filed by him by date of promised delivery), and for the receiving clerk. Copies were also furnished to other departments as needed, for example, to requisitioner, stores, accounting or financial, and vendor's inspection department. To write these numerous copies a flat bed billing machine and carbon paper were used.

The vendor's copy had attached to it a correspondingly numbered acknowledgment, which was to be mailed back, with space for promise of date of delivery. The follow-up man acted to secure shipment on this date, keeping contact with the vendor until the goods were shipped, when the bills of lading were turned over to the traffic department for any necessary follow-up of transportation companies.

THE A. B. C. MFG. CO.,
CHICAGO, ILLINOIS
PURCHASE ORDER

Our Order No. 7601

This order number must appear on each invoice and package

Messrs

Date ordered ________
Date shipment required ________
Ship via ________
Inspection ________
F. O. B. ________
Terms ________

Please furnish us with the following material, subject to conditions

QUANTITY	PART OR PATTERN NO.	MATERIAL	PRICE

CONDITIONS

Mail separate invoices for each shipment on above order.

If your terms are other than those stated in this order, please advise when acknowledging.

No charges are allowed for boxing and crating except where specified.

There is no verbal understanding or agreement different from the conditions stated in this order.

This order subject to modification in case of fire, strikes, or other conditions beyond our control.

It is understood that promptness of delivery as specified is of the essence of this order.

Unless otherwise agreed in writing the sellers of these goods agree to assume the defence of any suit for infringements of patents brought against this company by reason of the use of such goods and to indemnify this company against any costs or damages in such suit.

Signed ________
Purchasing Agent

Acknowledgement of receipt of order

Upon receipt of above order please sign, detach and return this acknowledgement at once to

Purchasing Agent,
A. B. C. Mfg. Co.,
Chicago, Ill.

Have received and entered your Order No. 7601 for execution as therein specified

Date received ________ Signed ________

Our Order No. ________ ________

FIG. 37.

PURCHASE ORDER.

When the invoice was received it was turned over to the invoice checking division and filed by the order number. When the goods came they were unpacked by the receiving department, and a receiving slip was made out giving quantity, item, order number, and vendor's name. One copy of this receiving slip was sent with the goods to the inspection department, and if O. K., to stores. The original of the receiving slip was checked with the receiving department copy of the purchase order, and if O. K., was sent to purchasing department as notification of receipt. It was there matched up with the invoice previously received and filed with the original purchase order. If all was correct the invoice was approved and turned over to the accounting department, checked for price and extensions, posted to controlling material account, and approved for payment, care being taken to pass invoices promptly so as to be able to take advantage of the usual discount for cash within ten days. If the material failed to pass inspection the purchasing department was at once notified to hold up payment. If the material was found up to specification it went to stores, a copy of the receiving slip accompanying it and clearing through the stock records as a record of receipt.

In a smaller department the organization would be much simpler, but the essential steps would still be taken. We might find a purchasing agent and assistant, acting as buyers, a follow-up man, and a stenographer who also checked invoices, getting them ready for the purchasing agent's approval.

This is the typical routine of operation of the purchasing department. The "P. A." has a number of big problems, which make his work important in spite of the simple routine and small organization required.

Purchasing Policies.—Upon the purchasing agent depend the important choice and knowledge of sources of supply. Perhaps a new product is being developed, involving some items not previously bought. Usually there will be someone somewhere who is already producing the item, at prices far

lower than it could be made to order. To find this supplier and to find just the right material and the most reliable firm as to price, quality, and service, are tasks often taking weeks. To aid him the purchasing agent usually has a file of catalogs and supply firms, classified by product, he reads the trade papers, visits conventions, and sometimes makes exploration trips to distant parts of the world. Oftentimes, through his contact with salesmen of other firms, the purchasing agent is able to suggest valuable economics through substitution of better or cheaper materials, improved machinery, and other new things which have come to his attention.

The buying policy is another important part of his work. Shall the firm divide its business, gaining the advantage of independence of any one source of supply, and better knowledge of prices, or shall it give one firm the whole business, securing possible price concessions and better service and various other preferences given larger, steady, exclusive customers? When has the seller made his best price, when should the buyer stand out for a lower price or better terms? The purchasing agent's work involves good judgment, diplomacy, and occasional battles of wits. But there is a seller's good will, as there is a customer's good will, and the wise purchasing agent guards carefully his firm's reputation for fair play and honorable dealing, that he may, in time of trouble, have friends to whom he may turn for emergency deliveries, for help in time of over-extended finance, for service and suggestions that will aid him. The purchasing agent is constantly being proffered courtesies, favors and more concrete presents from interested sellers, and the work requires a peculiar delicacy of moral sense.

Because of the peculiar temptations offered in the handling of material it becomes necessary to take certain precautions against fraud. The purchasing agent will usually be a man whose probity has been tested in other work by the company, or who has a favorable record with other companies. His position and salary are such as should satisfy and hold a good

man of good caliber, giving him a stake he will be slow to jeopardize by doubtful conduct. He is in fact often made an officer of the company for this reason.

In addition to this, as should be done in all cases where there is a temptation to which men may possibly yield, there should be an automatic, impersonal check on the work of his department. One such check is the separation by which purchasing, and storage and often receiving are made independent departments, each making its own reports and records, thus making a more elaborate degree of collusion necessary to successful peculation than is commonly easy to obtain. Performance and inspection records should also be kept which would quickly reveal any extensive fraud due to shortage or a substitution of inferior grades.

In purchasing, the use of material, payroll frauds, and other common points of temptation ninety out of one hundred men may be counted on as honest, a few will be honest when not subject to special temptation, and possibly the hundredth man may be deliberately dishonest. Proper supervision and check of all alike need imply no suspicion of the honest man, it removes temptation from the weak man, and it stops a leak which soon assumes large proportions if a deliberately dishonest man happens to join the organization. Undetected dishonesty is especially dangerous because it is contagious.

Contracts.—There are several common plans for buying. Small or occasional items are usually bought in the open market or from jobbers, price being asked before the order is placed. For larger occasional purchases, such as machinery, buildings, etc., competitive bids are often advertised for, the lowest or most favorable bid being accepted. Where the firm habitually purchases a certain item or items from one firm, the order is often sent in to be filled at the prevailing price, the good faith of the vendor being relied upon to prevent overcharge. Probably the bulk of large factory purchases, however, are made under some form of contract, by which the buyer obligates himself to take a quantity of ma-

terial which is delivered as needed. The contract may be for a specific tonnage or amount, to be delivered at a specified rate or within a specified time. It may call for a specific amount to be delivered as needed. It may call for the firm's whole requirements for a period, these requirements being estimated approximately. Price may be stated, or deliveries may be made at market price. The contract may be an actual obligation to accept a specified quantity, or it may be in effect merely an agreement as to price and the willingness of the vendor to supply a certain amount, the buyer not being obligated until specific orders are placed under it. A typical contract is shown in Figure 38.

Quantities to Purchase.—An important question in material supply, after the design is decided upon and operations are started, is the decision as to the quantities in which materials shall be purchased and carried in stock. As pointed out in Chapter IV, the material supply system may be likened to a reservoir system, the supply pumps of purchase or production orders being either operated only as required (special order), intermittently between a float or stock limit controlled high and low level (lot repetitive), or continuously, the float or stock limit acting only in emergency (flow repetitive). On the perpetual inventory record of stock on hand, kept for each item of stock, a minimum is specified, at which a new order must be placed, when stock falls to this limit, and the number to order, or the high limit of stock, is also specified. (See Chapter X for discussion and illustration of stock record forms.)

The question of storage is an incidental one only, in many strictly special order industries. In job printing, for example, storekeeping is often mainly a question of properly caring for and recording customer's materials, such as paper stock. In the flow repetitive industry materials are usually purchased in large lots under contract, and delivered according to a schedule which is closely controlled by current sales and needs, only enough reserve stock being carried to meet emergency

IN DUPLICATE.

Blank Manufacturing Company. Akron, O., April 10, 19...
Memorandum of Sale.

....

....

................................Buyer

hereby purchases and agrees to receive from the Blank Manufacturing Company and the said Blank Manufacturing Company hereby sells to .... the following material, under the conditions and terms hereby agreed upon.

Quantity and description	One hundred (100) tons mild steel band, 1″ No. 12, 16 ft. length, not over 10% of short length to be included.
Delivery period and specifications	Specifications shall be furnished to the seller by the buyer in substantially equal monthly quantities. Failure by buyer to furnish specifications may at seller's option be considered as waiver on the part of buyer of all right to demand any of the unspecified portion of the goods. Specifications are to be furnished by buyer not less than ten days before date of shipment.
Shipments	To be made in three approximately equal shipments of one carload each, commencing June 1, 19.....
Price and terms	Two dollars and eighty-five cents ($2.85) per hundred pounds, F.O.B., Chicago, Ill., net 30 days, with a discount of one-half of one per cent for payment within ten days from date of invoice. If any quantities are called for to be shipped in less than carload lots, these shall be shipped F.O.B., Akron, O., and an extra of twenty-five cents ($ .25) per hundred pounds shall be added to the above price.
Remarks	Payment to be made in U. S. gold coin or its equivalent in U. S. currency. Each month's shipment to be treated as a separate and independent contract, but if buyer fails to fulfill terms of payment under this contract, seller reserves the right to defer shipments or cancel this contract. Strikes, fires, accidents to machinery, or other contingencies beyond the control of the seller shall be considered a sufficient excuse for any delay in shipment traceable to such cause. Accepted for buyer .... Per .... Accepted for seller .... Per ....

FIG. 38.

CONTRACT FOR MATERIALS.

fluctuations in demand or supply. The largest stocks, relative to volume of business done, are usually found in the lot repetitive industry, where unit parts and often complete articles are made up in comparatively large lots and carried in stock until the lot is nearly exhausted.

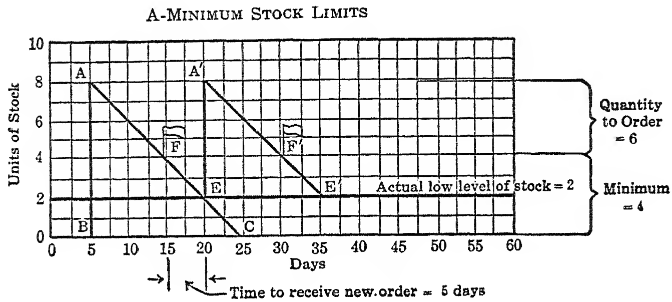
In both the flow and lot repetitive types, however, the determination of the maximum and minimum stock limits, and consequent average stock and size of lot to purchase or make, is an important executive function. These limits are usually set by the chief storekeeper after consultation with the purchasing agent and manager or superintendent, and they are revised as market and other conditions change substantially. If an order was given by the financial executive to "reduce inventory" it would mean a downward revision of these limits.

Affecting as it does the very heavy investment of working capital in materials, the correct determination of these limits is an important matter. Certain theoretical considerations affecting the decision will be discussed first, then the practical considerations involved, which are based in part on this theory. In a simple and conventionalized manner we may graphically represent the quantities of materials on hand at any time, assuming that it is ordered in lots and issued at a uniform rate. Figure 39 illustrates the day-to-day variation in the quantities of a particular item of stock under these simplified assumptions.

If we ordered a lot of eight on the fifth day, the stock on hand would immediately rise from zero to eight (AB, Figure 39A) and if used at the rate of two every five days would again fall to zero at C. Since irregularities in supply must be considered we do not want to completely empty the bins this way, and the ordering of a new lot must be timed so that normally we will have a small reserve as at E still on hand when the new lot is received. Since time will be consumed in receiving the order, the actual minimum limit must be higher still, say at F, if it takes 5 days to receive an order. The minimum is a sort of danger signal and its quantity should

be the normal time in days to receive an order, multiplied by the average quantity used per day, plus the amount carried as an emergency reserve.

A number of factors influence the setting of the maximum.



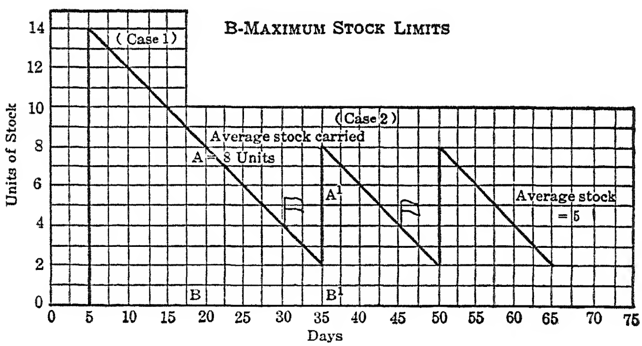


Fig. 39.

DETERMINATION OF STOCK LIMITS.

In Figure 39B the stock on hand is represented as in Figure 39A, but on the assumptions (1) of an order every thirty days and (2) of an order every fifteen days. Evidently the total material ordered per month is the same in each case, but in case (1) the average investment (the average ordinate AB,

eight units) will be nearly twice as great as in (2), where the average ordinate A^1B^1 is five units. If the stock was drawn to zero each time the average stock would be twice as great in (2). There are a number of costs of a nature similar to this cost of interest on the investment, which may be grouped as *carrying cost,* and which increase approximately proportionally to the size of the order or maximum limit. Interest on investment, storage charges, insurance, rehandling charges, and depreciation and obsolescence (the risk of going out of date) are charges of this nature.

On the other hand, every time an order is placed, there is a certain expense in the nature of *preparation cost.* The clerical cost of putting through the order or the expense of machine set-up if the goods are made in our own shop is incurred whether the order is small or large. Of the same nature, because existing for the same reason, are the higher freight charges on less than carload shipments and the quantity discounts on large orders. This class of expenses is very high per unit on small orders, but as it is spread over larger and larger quantities, it tends to become relatively insignificant. It is opposite in character to the carrying charge. The correct point to order, or size of lot to manufacture, may be obtained as the point at which the sum of the two is least. This point is susceptible of mathematical determination, but a simpler representation of the idea may be given by the curve shown in Figure 40, where A represents the carrying costs of fifty cents per unit of stock for interest, etc., uniformly increasing as the size of lot is increased, while the preparation cost of eight dollars falls off in a descending ratio as it is applied to an increasing size of lot, as shown by curve B. C is the sum of the ordinates of A and B for each size of lot, and the lowest point in C, a lot of 4, would evidently be the correct size of lot.

But while this curve represents excellently the theory by which size of lot would be determined, there are other independent variables so large that the executive is usually content

to forego actual computation and rely on a more approximate judgment, mentally balancing the same elements.

Carrying charges and preparation costs act uniformly and oppositely. But market considerations swing now one way, now another. Large profits are sometimes made by speculative buying, but in the long run the wise policy is to buy for normal needs only and to avoid speculation in materials. In fact, in the highly speculative lines such as grain it is quite common for the manufacturer or miller to "hedge" by selling futures

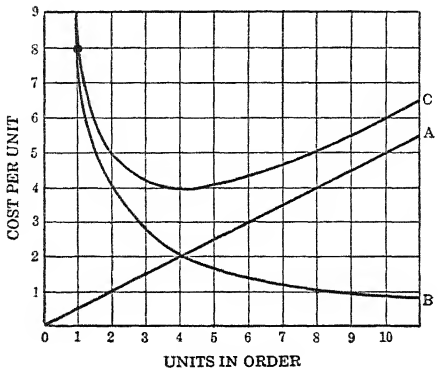


Fig. 40.

CURVE SHOWING QUANTITY TO ORDER.

equal to the amount he buys, so that whether the price of flour, in sympathy with grain, goes up or down, he will neither gain nor lose on buying but will be sure of his manufacturing profit. Market conditions, however, normally affect buying policy considerably. We buy from hand to mouth in periods of falling prices and endeavor in some measure at least to protect ourselves in anticipation of expected raises in price.

Other factors such as certainty of supply enter to complicate the problem at times. The year 1922 for business was one of recovery from a heavy slump. In addition to complications due to coal mine and railroad strikes, many of the

basic manufacturers such as steel had been operating at only a small per cent of normal capacity and were unable promptly to expand their crews to meet the expanding volume of business. Careful study of and preparation for such emergencies is vital to continued and smooth operation, and to the avoidance of the high material costs and uncertain quality incidental to picking up small emergency lots of material from new sources, securing material by express shipments, and similar emergency expedients.

Information as to Price Tendencies.—The purchasing agent will be interested, equally with the financial man, in market and trade tendencies. Available as sources of information on this point he will have the trade journals, his own personal impressions gained from contacts with other companies, the records and reports compiled for and used by other company executives, the financial reports issued by agencies such as Dun and Bradstreet, and the Harvard, Brookmire, and Babson market reports.

Standardization.—A field in which the purchasing department may often effect substantial economies is in the standardization and budgeting of purchases. Thus stationery and forms may be gone over, useless forms eliminated, extravagances in multicolor printing, ruling, paper stock, cuts, etc., eliminated, and departments persuaded to purchase in larger quantities and at regular intervals. Often a quarterly estimate of needs is made by each department and fixed as a budget, furnishing the purchasing department with the opportunity to plan in advance and to combine purchases, and the financial department with an estimate of departmental expenditures. Some years ago the Pennsylvania Railroad, through its engineering department, worked out a complete set of standard specifications for track, hardware, and all other materials customarily used on this road. The Society of Automotive Engineers has effected heavy economies for the automobile trade by reducing sizes of bolts, studs, nuts, carburetors and other accessory connections and many other

parts and dimensions to standards which have been generally adopted by automobile manufacturers.

One of the recent developments in the field of purchasing is cooperative purchasing, by which a group of retail stores, or the members of an association of manufacturers in the same trade, pool their purchases through a central purchasing bureau, securing the advantage of quantity buying and carload shipments.

Traffic.—On account of the complicated rulings as to classification and tariffs on freight shipments, a considerable saving may often be effected by a man versed in tariff regulations, through correct description of goods to secure the most favorable classification, proper packing to conform to classification rules, taking advantage of commodity rates, and routing of shipments for most expeditious delivery. The traffic man also aids in tracing delayed shipments, brings pressure to bear to secure prompt delivery, checks for correctness of charges and handles freight claims. This service is performed both for outgoing and incoming freight. The traffic manager may report to the general manager, or, according to whether out freight or in freight is the more important, to the sales or the purchasing department.

Receiving.—The routine and general organization of this department have already been described in Chapter IV. The department is usually a small one, equipped to unpack, count, and record incoming shipments, reporting receipts, in duplicate, to the stores and purchasing department. Closely related physically to the receiving department is the vendor's inspection department. This department is equipped with specifications covering all inspected purchased materials, and with gages and physical and chemical laboratory equipment necessary for determining conformity to specifications. If possible it passes on material before payment. Where flaws develop afterward, in the process of manufacture (as in the case of castings with blowholes, etc.) there should be an agreement by which the defective parts are periodically sur-

veyed jointly by a representative of the vendor and of the inspection department, and credit given or the parts replaced. It may be necessary to mark rejected parts to prevent an attempt by a dishonest vendor to get them past the inspector on a second shipment. In general, the purchasing and receiving of material require especial safeguards against the possibility of various forms of dishonest dealing.

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CHAPTER X

STORES

THE work of the stores department naturally divides itself into two parts: first, the accounting for and control of quantities, usually performed by a stock records division; second, the actual physical handling of the materials, receiving, counting, locating them, and delivering them on requisition as needed. Because of the very intimate relation between stock records and production control, the stock record department is often located in the planning or production department, reporting either to the chief storekeeper or to the head of the planning department for orders. Frequently the physical storage is divided as between raw materials or stores, and finished parts or stock. This distinction is by no means rigidly made, however.

Accounting for materials involves some form of record of receipts and disbursements, of which the most typical is the balance of stores record or perpetual inventory. Various purposes may be served by such a record. Its amount, "balance on hand," gives a figure by which the total stock on hand of any article or of all articles in stores may be ascertained, for making up financial statements, for proof of loss in case of fire, for fixing responsibility in case of fraud or theft, and for making production plans and promises to customers. Varying with the purposes for which it is intended, the stock record ranges from a simple in-and-out record of quantities to elaborately detailed forms.

Typical Stock Records.—A very simple type of record is that kept by a large steel jobber, who carried in a loose leaf ledger a sheet for every item of stock carried. The heading

of this sheet contained the description, symbol, and location in the store room, of the article. As the item was drawn from or added to stock, the amount only was added or subtracted from the current balance, and a new balance on hand shown. A date stamp was entered in the column monthly, making possible a rough check-up on any particular transaction, or a quick summary of volume of sales. Evidently the only means of locating errors in this record would be by physical inventory, and the record would in other ways be inadequate for most situations, but in handling numerous small withdrawals,

Name of Part ________ When quantity falls to ________ Part Symbol ________

Place order for ________ Location in store ________

________ Unit (each lbs. dozens) ________

ORDERED			ON HAND					REMARKS
Date	Order No.	Quantity	Date	Order No.	Amt. Rec'd	Amt. Issued	Balance on hand	

Fig. 41.
STOCK RECORD.

with adequate reserves always on hand, and in working with an item issued in definite units, not very liable to confusion or tempting to theft, this record would perhaps answer all purposes.

A more usual type of record is shown above in Figure 41.

The part symbol will usually be placed in the upper left hand corner, as it is the handle by which the card is located in the files. As material is ordered it will be noted in the "ordered" column. As it is received, the appropriate order number will be crossed out and the date, order number, amount received, and balance on hand entered in the "on

hand" column. Similarly issues of material will be entered and subtracted from the balance on hand. The "remarks" column will be used for noting stock to be reserved for special orders, or for any miscellaneous notes not otherwise provided for.

Where it is frequently necessary to reserve stock for use on special orders, it becomes desirable to use a form specially

Description________________ When quantity falls to ______ Symbol______
Place order for ______ Location______
________________ Unit________

1 Ordered					2 On Hand					3 Apportioned					4 Available			
Date	Order No.	Quantity	Total on Order	Unit Cost	Date	Order Number	Quantity Received	Quantity Issued	Balance on hand	Date	Order Number	Quantity Apportioned	Quantity Filled	Total on Order	Date	Quantity	Total	Remarks

To check arithmetical correctness of entry, columns 1 + 2 should equal 3 + 4

FIG. 42.
STOCK RECORD.

providing for this entry and for showing the balance available for new orders as well as the balance on hand. The extra work of this apportionment is not needed if the stocks usually carried are large relatively to the size of the usual withdrawal, as in this case the maximum and minimum stock units are usually a sufficient protection against exhaustion of stock.

In the lot repetitive industry, however, and in many other cases, we frequently find that only enough of a supply of unit parts or raw material of one pattern is carried to fill one or two orders, and if stock if not reserved under these conditions and orders for additional supplies placed promptly upon receipt of the customer's order, stock might not be available for any particular order, having been used up on other orders. Figure 42 shows a form suitable for this purpose.

As a purchase order is placed for the material, it would be entered under section (1), "Ordered," giving date, purchase order number, amount, and by addition to previous total, the total number on order. It would also be entered under section (4), "Available," since under normal conditions the stock limits would provide a sufficient reserve so that the purchase would actually be received before supplies in hand were exhausted. The amount "available" under this interpretation would of course be subject to certain reservations, easily ascertained, however, by glancing at the "ordered" section.

As the goods were received, they would be subtracted from the "ordered" column, (1), and added under the proper heading to the "on hand" column, (2). Provision is made in this form for a unit price column, which makes it possible for the stores clerk conveniently to price requisitions for the cost department. Whenever the price of an item changes, a memorandum entry would be made in this column, on the basis of information furnished the stock record clerk by the purchasing or cost department.

When an order is received from the customer, the bill of materials is usually checked by the stores department immediately after leaving the engineering department. The clerk would at this point enter under section (3), "Apportioned," date, quantity, order number, and total on order, also subtracting the amount from section (4), "Available." If this entry reduced the available below the minimum specified under "when quantity falls to——" in the heading of the sheet, a purchase or manufacturing requisition would immediately be made out and sent to the proper department. The amount would be entered under section (1) and (4) as described.

When the apportioned order was filled, it would be subtracted from the "on hand" and "apportioned" column.

The record is self-checking for arithmetical errors, since if it is in balance, the sum of the balances in sections (1) and (2) will always equal the corresponding sum of sections

(3) and (4). Instead of using one line clear across the page to an entry, each column may be carried down independently, the date and order number serving to identify the entry. These records may be kept either on cards in an index, or preferably on sheets in a loose leaf locked binder, since in the latter case they may be removed when filled or obsolete, but are not easily borrowed by persons who forget to return them. Additional clearness is gained by entering receipts in red, issues in black, and by drawing a vertical check line opposite each item as filled, so that all closed transactions are indicated.

Bin Tags.—In a factory where the stocks are large and varied, representing an investment of considerable importance, and where it is important to be sure always of having an accurate and certain record of materials on hand with a minimum of investment, additional accuracy may be obtained by the use of check records in the store room. One form of check record is the bin tag, one of which is placed in a tin holder at each bin or for each item of stock. The tag headings provide for a simple in-and-out entry, with dates, quantities, and if needed, order numbers of the receipt or withdrawal, a balance on hand being always carried down. The bin tag presents several advantages where the increased accuracy is worth the cost. It provides an automatic check on stock records. At periodic intervals (say, when the tag is filled with entries or when the stock is practically exhausted) the tag would be sent to the stock record department. After reconciling it (after the fashion of reconciling a bank statement with a checking account) for entries which had cleared through one record and not through the other, the balances on tag and stock record should agree. If they do not, a count and correction can be made. The bin tag system also cultivates a feeling of responsibility and careful habits on the part of the stock men, since it is easy to check a man's work by comparing physical count with the tag balance. The bin tag is also an aid in inventorying.

Double-Bin System.—A variant of the usual system of having one bin for each item is the double bin system, in which a pair of bins is used for each item. The bins are alternately used for receipts and issues, all issues being made from one bin, and receipts being entered in the second, until the first bin is exhausted, when it becomes the issuing bin. A tag is kept for each bin, and forwarded to the stock record desk for check with the books at the change-over. This system also insures using up stock in each bin completely, preventing an accumulation of old stock in the bottom of the bin, to tarnish, rust, become dusty, or otherwise deteriorate with age and handling. This plan is of only limited application, however, because of the space and equipment required.

Issuing Stores.—The method of issue of materials to the workman is of practical importance. In certain cases the most economical method is to allow a specified workmen, or a group of workmen, to help themselves. Cheap bulk supplies and materials would probably be handled in this fashion, supervision being relied upon to prevent waste, and replenishment being either according to regular schedule, proportionate to the production orders sent to the factory, or by inspection, or by some system of physical stock limits. For example, a reserve bin may be filled or a sack of the material tied up and kept in the bottom of the bin. An order is placed when the regular supply is used up and the reserve bin is drawn on until the new stock is received. The method of issue in the case of a piano factory was as follows: (1) Lumber was bought on schedule, so many hundred feet in the various sizes and lengths for each lot of pianos, due allowance being made for waste and rejections. For the first process, all of this lumber passed through the hands of an experienced sawyer, who cut the parts to length in the rough, according to a bill of materials, and sent the parts to the various departments for further finishing. Detailed in-and-out requisitions and records would have been a waste of money here.

A second method of issuing materials is used in the repetitive industry or where the same standard bill of materials is regularly called for. In an automobile motor factory, the storeroom employed one or two men whose duty it was to make up "pan lists"—lists of unit parts required by the assembly line for the assembly of say seventy-five of a particular type of motor. These lists were furnished the morning of the day before assembly and were regularly ready the evening before assembly. The next morning the assembly material man got the pans, signing the list as a receipt, and distributed the made-up lots to the various stations on the assembly line. Similar plans of supplying parts without special requisition but in accordance with a schedule made up to correspond with the production schedule would be very generally found in flow repetitive industries.

Where demands for material are irregular and varied, recourse is usually had to a requisition presented to the stock man and filled by him after presentation. This requisition is signed by the recipient of the material, and clears through the stock record for entry of the transaction, and through the cost record for entry of job material costs. It may be made out by the workman or foreman as he needs material. In order to prevent waste the stock record clerk is sometimes provided with a check list or bill of material showing the amount of stock permissible to use for each item. As filled requisitions are noted against this list, and when the authorized amount has been withdrawn, special explanations and permission are necessary for further withdrawals. It is not in general a good plan, however, for workmen or even foremen to withdraw material as desired for irregular demands. Aside from the possibility of peculations with valuable material such as brass, hardware, etc., there is invariably a tendency to waste, drawing a little too much "to be sure I have enough to finish the job." The small surplus seldom finds its way back to stock, and is usually thrown away or wasted.

Where a planning department is used to control production, this department may also well control the requisitioning of material, the requisitions, along with the time cards and other working papers for the order, being written up in advance and put in a file by order number, and being drawn from the file and sent out as needed. Under this system the requisition may be given to a move material man, who draws the item from stock and delivers it to the proper machine before the time card or work order is given to the man starting the

Name of Part ________	Symbol ________ Location ________
Quantity ________	Kind of unit ________ Cost per unit ________ Total value ________ Date ________

Storekeeper: Please issue above materials

To ________ Dept. Signed ________

Apport-ioned	Bin Tag	Bal. Sheet	Cost Sheet	Received
✓				Signed by Storekeeper or his representative

FIG. 43.

MATERIAL REQUISITION.

job. These requisitions then clear through the stock record and job cost sheet in the usual way.

Figure 43 indicates the form of a typical material requisition.

Using one of the described systems of checking the stock records and with a well trained crew of stock men, it is possible to secure very accurate records without special periodical inventory, but under usual systems and even under this system, there are so many chances for inaccuracies in count, withdrawal without record and other errors to creep in that custom wisely decrees a periodical complete inventory and physical count of all materials on hand.

The usual method of doing this is the annual or semi-annual inventory, taken usually at the close of a fiscal period as a basis for a correct financial statement.

Taking Inventory.—Simple though it is in theory, the taking of a good inventory in practice requires careful organization and a trained crew. Where a complete order cost and stock record system is in effect the inventory of work in process is obtained rather simply by totaling the expenditures on the job cost sheets as of a certain date. Where continuous cost records are not compiled the much more difficult and inaccurate method of estimating stages of completion must be used. The shop will usually be divided into sections and a crew (usually including the foreman of each section) will be selected and trained in advance. Numbered duplicate tags will be made out and blocks of tags assigned to the captains of the crews. On the day or days (sometimes two weeks are required) of the inventory the plant will be shut down and all but the inventory crew, office help, janitors, etc., temporarily laid off. A crew inventorying work in process for a certain section will be divided into two groups, one group taking the inventory, counting each lot of material at the machines, on the floor, shelves, etc., of the section, entering the count on the tag and attaching the tag to the lot. They will also estimate and enter the value of the work or the percentage of completion. The second crew then follows the first, checking the count, seeing that no items have been overlooked, and detaching one half of the tag, the other remaining attached to the work for later checking if needed.

A similar procedure will be followed in the storeroom except that there is no need here for estimate of completion or cost. The collected tags will now be sorted into numerical order to make sure no tags have been overlooked, and as fast as each crew accounts for its block of numbers it will be dismissed.

The tags will now be checked with the stock records, the date and word "inventory" usually being stamped opposite

the correct balance in the "on hand" column. Usually some discrepancies and overlooked items will be discovered in this process. Prices will now be extended and checked, the cards arranged by classes of materials, and the totals for the financial inventory figures drawn off.

A very simple and expeditious method of taking inventory without interruption of operations is possible where bin tags are kept and stock records are in good order. Two or three

INVENTORY CARD
ORIGINAL

Part Symbol
Tag No. 21844

Date ____________

Name of part ____________________

Dept. ________ Location ________ Kind of material ________

Date	Order No.	Quantity	Bal. on hand	Cost Each ________ Value ________

Counted by ________	Extended by ________	Checked by ________

FIG. 44.
INVENTORY CARD.

weeks before the official date of inventory, blocks of numbered duplicate tags, as previously described, are distributed to the various stock record clerks. The headings of these tags are then filled out from the stock records, with name, description, symbol, and location of the item, one tag for each item open on the books. These tags will next be matched up with the various bins and slipped into the bin tag holders with the bin tags. If there are any unaccounted tags, or bins for which there are no tags, the discrepancy will be checked up and the stock record clerk notified. The inven-

tory tag (Figure 44) is provided with spaces for several entries. As opportunity presents, the stock men count the articles in one bin after another, entering the total on the bin tag with date. Subsequent issues or receipts will now be entered as made, without interrupting the regular operation of the storeroom. On the day of the inventory, the entire clerical force of the stock record department, with additional help if needed, and with proper preliminary drill and organization, comes into the storeroom and "pulls" the tags. A first man transfers the inventory count and subsequent entries from the bin tag to both copies of the inventory tag. A second man checks the correctness of the transfer and detaches one half the inventory tag. The tags are now sorted numerically and checked through the records as before described, then sent to the accounting department for extension and totaling.

Pricing.—If the order cost system is used for ascertaining manufacturing costs it is necessary to price the material called for on each requisition. Pricing is necessary also when inventorying, since there are frequent fluctuations in market, and since different lots of the same material may be bought at different prices. Sometimes the information as to material prices is kept in the cost department, and only the quantity issued is entered on the requisition by the stores department, the requisition being priced and extended by the cost department. Some labor is saved, however, by furnishing the stock record clerk with the prices and allowing him to enter the unit price at the time the requisition clears through the stock record. This requisition is then extended for total cost in the cost department, and posted to the cost sheets. A controlling inventory giving the money value of the materials on hand, by broad classes, is often kept, and where this is the case the priced and extended requisitions and receiving slips will be totaled by classes and entered in this controlling inventory.

Sound accounting practice dictates that for inventory purposes materials shall be priced at "cost or market, whichever

is lower," the theory being that profits are not to be anticipated, but losses are. While the records will therefore be adjusted for inventory on this basis, for entry to cost sheets the material is usually priced out at cost unless there have been very heavy changes in market prices. This practice greatly simplifies the accounting, since with a proper plan of pricing, issued materials will go out at the same price as when received, keeping the financial inventory in numerical balance.

Where prices fluctuate there are several plans of pricing at cost. One of these is to price out each lot at its own cost, using up the lots in order. Thus if ten are received at ten cents each, then twenty at twelve cents and an issue of fifteen is made, ten of the fifteen would be priced at ten cents, the remaining five at twelve cents. A second accurate method is the use of the running average cost. Suppose ten received at ten cents, and five issued, leaving five on hand, then ten more received at thirteen cents. There will now be fifteen in stock, at a total cost of $5 \times .10 = .50$, $+ 10 \times 13 = 1.30$, or 1.80, a unit cost of 12 cents each. Issues will be made at this price until a new lot is received, when a new average price will be computed.

A special problem of stock recording is presented where "crop ends" cut off from full size steel angles, etc., and various other kinds of remnants are to be accounted for. Where the practice will not seriously affect customer's cost and the piece is not over a certain size, it is sometimes the practice to charge the order and credit stock with the full length. The stock cutter then holds the odd length until an opportunity occurs for its use, when it is used up without record. Sometimes a special record is kept of odd pieces, which is used by the engineering department in working in these pieces where possible.

Handling Wastes.—While partly outside the province of regular stock record work, the handling of usable and salable wastes presents a problem in material handling. Brass turn-

ings, steel turnings and trimmings, leather, rubber and cloth remnants, copper wire, waste paper, oil extracted from oily waste, from machinery, etc., type metal, packing lumber and containers, and a wide variety of wastes are constantly accumulating. In the very small plant it may not pay to salvage these, but in the larger plant it is profitable to provide separate receptacles for the various kinds of metal turnings, or magnetic separators, waste baskets and containers, oil filters and centrifugal oil collectors to remove the oil from metal turnings, and other similar devices for collecting, grading and reclaiming these waste products. The material so reclaimed will properly be entered as a credit to the appropriate materials account, at its reclaimed value.

Counting.—Turning next to the physical handling of stores, we pass logically to the process of counting. If material is counted by the inspector the stores department will usually accept his count, but in issuing materials and in much miscellaneous receiving, a good deal of time is spent in counting, at best rather an inaccurate process when humanly performed. Counting scales and other mechanical methods are therefore frequently used. In the counting or ratio scale a certain number of the articles to be counted are put in the scale pan and used instead of a counterpoise, being moved along the scale beam until a balance is obtained, when the count can be read off directly on the beam. Another method both of counting small articles and preserving them during handling is to place them as made or inspected in trays having, for example, one hundred compartments, or in packages of a uniform size.

In certain cases it is only these unbroken packages which are recorded by the storeroom. Thus in many of the large mail order and wholesale houses only bulk packages are inventoried. As a department stockkeeper exhausts the supply in the bin, a new package is ordered and charged out of stock. Withdrawals of the units are not recorded. This is, of course, a looser method and might lead to waste in many cases, but has been found profitable here because of the very

small value of the average item which would have to be recorded. Other methods of preventing theft or waste are resorted to, to supplement the stores record.

Symbolization.—A second problem in the physical handling of stores is that of identification and symbolization. Names are used loosely and inaccurately, and the description is often incomplete. Thus a foreman who used only one kind of bar stock would be apt to order say ten feet of bar, which obviously might mean any one of fifty kinds, sizes, grades, and shapes of bar. Some system of positive brief identification becomes necessary. One system is that of simple consecutive numbering without any attempt at classification. This is probably the commonest system of cataloging the various complete products of the company, thus pattern or model No. 1, 2, 3, etc. Where articles divide themselves into classes or groups, however, the system is made much easier and clearer to remember, use, and expand if some systematic plan of classification is adopted. The Dewey decimal system in use for classifying books for libraries is a good illustration of such a systematic classification. Three digits are used, followed by a decimal point and as many additional digits as are necessary (combined also with a letter for the author's name). The first digit indicates the place of the book in a primary classification of the fields of human knowledge such as dictionaries and encyclopedias, social sciences, natural sciences, fine and applied arts, fiction and other groups. Thus 600 indicates the applied physical sciences. The second digit indicates a sub-class, as 20 for mechanical engineering, and so on, each digit representing a subdivision until the individual book or item is reached. This system is much used in the classification of accounts, the first 100, for example, being reserved for general administrative expenses, the second hundred for sales expenses, the third hundred, shop expenses, etc., with say the tenth hundred and upward for customers' orders. (See Figure 56, Chapter XIV.)

If letters are used instead of digits we have the Mnemonic

System. This has the advantage that the letter may be made to suggest the class, and that with some twenty-two letters (i, o, q, and u are omitted because likely to be confused with other letters) more members may be included in a class than with the ten digits in the decimal system. Thus if we take the arbitrary pattern number of a complete article such as a lathe as a basis, we might have for lathe number 21, 21C, the carriage group, 21CA, the apron, 21CT, the tool holder, 21CTP, the tool post, and if more than one pattern of tool post were used, the various patterns could be called 21CTP1, 21CTP2, etc. Care must be used not to carry the system out to its logical extreme when this involves a very lengthy cumbersome symbol, and frequently a combination of letters and numbers may be used which is sufficiently flexible to be expanded to identify new classes, and at the same time is specific and reasonably brief. Formidable as these symbols appear at first, the various sections of the classification soon become familiar to the men who use them and such a symbol as 2LTA1, the symbol for an automatic turret lathe, class two, machine No. 1, instantly brings up the words, as would shorthand, to the mind of the man using the symbol.

In addition to the classification of stores there are necessary in the factory several other series and classifications which may be mentioned at this point. The classification of accounts has been referred to. Machines, tools and work places must also be identified. Some system must be used for quickly indicating a specific location in the factory—usually done by lettering aisles A, B, C, etc., one way and numbering them the other, and by lettering or numbering floors and buildings. Employees are also identified by check number—frequently on the order of the decimal system, the first two digits representing the department number, the last two or three the man's number.

Locating Stores.—Closely related to the question of identification of the item by some systematic classification, is the question of locating it in stores so that it may be quickly

found. Two general systems are used here. Where the parts all pertain to one general assembled product or for other reasons are usually carried in about the same relative quantities from one season to another, they are usually located in the storeroom by a classification. Thus a section may be reserved for the lathe carriage parts, and all the various patterns of the respective unit parts, brought together in similar groups. Or a section is given over to bolts, and the bins are arranged in order, first by type, next by diameter, next by length, etc., of bolt.

Where stocks fluctuate widely, however, this system would tie up a good deal of space, since a part at one season might be heavily stocked and at another not at all. Here it is usual to number the bins in the storeroom and assign new items to any convenient bin, locating an item by cross reference to a location number carried on the stock record sheet, or in a special part index file.

Some additional points may be noted as to the physical care of stores. Appropriate racks and shelving must be provided. Unit shelving of wood or steel is largely used, so laid out that large compartments, say three by three feet by two and one-half feet deep, may be successively subdivided by inserting standard partitions to any desired size of compartment or drawer. With this system the stockroom space may easily be remodeled when desired.

Neatness should be very rigidly enforced. Where open spaces are needed for piling, aisles should be marked off with paint, and all aisle spaces required to be kept clear. Neatness in the storeroom is the mother of accuracy, and contributes generally to the morale of the stock men, who usually are not high paid men.

A first requisite of accurate storekeeping is that the storeroom be kept locked against all comers except general executives who may be relied upon not to touch the stores, and that nobody but stockkeepers be allowed to handle material. Generally it is best as far as possible to assign one

stockman a section for which he is responsible, all receipts and withdrawals being handled directly by him or under his personal supervision.

The same divisional plan of organization is in most cases best adapted to the record work. One clerk should handle one group of books or cards exclusively, making all in and out entries. Then he can be held responsible for the neatness and accuracy of the record, and will come to have an intelligent knowledge of the items he controls.

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CHAPTER XI

PLANNING

In Chapter III manufacturing was classified as of special order, lot repetitive, and flow repetitive types. From the standpoint of the movement of material through the factory we may reduce this classification to two types. In the case of the special order and lot repetitive industries material moves from process to process in intermittent lots, and there may be wide differences in the order of flow of successive lots, from one process to another. One lot may move from the foundry to a lathe in the machine shop, next to a drill press, next to a milling machine, next to assembly. Another may require additional processes, may omit certain processes, may move to the machines in a different order.

In the case of the flow repetitive type of manufacturing we find that instead of moving in intermittent lots, material flows in a steady stream. The volume of this stream may increase or diminish or suffer occasional interruptions, but each process is related to the next in a definite order and ratio.

Manufacturing Lots.—The problem of controlling this flow of materials involves several elements. It is desirable in the first place, although not invariably essential, to be able to identify the material in its progress through the factory, so that we can tell what portion of the raw material arrives in the form of finished goods, and what proportion as waste, also what the cost of the labor and material expended on the order amounts to. The usual method of identification of the order is to give it a lot or shop order number. This lot num-

ber is shown on a tag attached to the goods which travels through the shop with the goods, and which makes it possible at once to identify any lot of material which has been misplaced. (See Figure 25, Chapter V.) Frequently two or three lots of the same article are in different stages of manufacture for different customers, or they may superficially be identical but actually be different (as in the case of rights and lefts). The lot number then prevents confusion. It is also convenient in collecting the costs of manufacture. As new material or labor are expended, the requisition or time card is marked with the job or lot number. At the time the job is started a cost sheet is made out and filed by the lot number, and as the filled requisitions and time cards are received the costs are extended and collected under the proper lot numbers on the respective cost sheets, being thus conveniently totaled at the completion of the job. This order or lot number system is in very general use with the intermittent flow type of manufacture. It is sometimes also used in the continuous flow type, numbered lots of the material being passed successively through the various process, the identity of each being preserved to the end. This greatly facilitates identification and check up of loss in process, but as it involves additional accounting is usually abandoned in favor of the simpler plan of allowing material to flow through in an uninterrupted stream. Loss of material in process could be obtained in this second plan by inventorying, the equation being:

(Total raw material issued to the process)
Plus (Amount in process at previous inventory)
Minus (total material delivered as finished product)
Minus (amount in process this inventory)
Equals (loss of material in process for the period)

The inventory of material in process would be taken by actual weighing or counting of the amounts in the various stages, making proper allowance for normal reduction of weight in machining, etc.

Moving Material.—In addition to this problem of control, that of identifying the material in a lot, a second problem arises in the movement of material from machine to machine. Material does not move itself. In the flow repetitive industry it is sufficient to start the right amount of material at the first process, and the men at subsequent processes will know what to do without special orders. But in the interrupted flow types directions must be issued, either to the workmen or to a special move material gang, for the movement of each lot to the next operation at the completion of each operation. This may be provided for, by showing on the tag attached to the lot the successive machines to which it is to be moved. (See stub tag, Chapter V, Figure 22.) Instead of depending on the instructions given on the tag attached to the job, and on the orders of each local foreman in whose department the job happened to be, for its movement to the next operation, its movement may be controlled by another plan, that of movement by a special "move materials" department which acts on orders from the planning department. Using this system a move card would be prepared which, like the stub tag attached to the work in other systems, shows in sequence the various machines at which work is to be done. But this card is not attached to the job, but held in the planning office and sent out as an order to move the work when each operation is completed. It would be sent out with the requisition on stores, as an order to move to the first operation. The move man would return it, signed by the foreman receiving the material, and it would be held in the office till again needed to move the material to the next job.

Machine Scheduling.—A third problem is that of regulating and controlling the program of each machine or producing group. In the flow repetitive type this control is nearly automatic, since the whole factory may here be considered as a single producing unit. The only problem here, granting proper supply of raw materials, is to keep the various stages of the process in step with each other to prevent an accumu-

lation at one department due to lagging, and a shortage at the next.

But in the intermittent flow types the work does not come automatically to the machine. There, instead of flowing in one steady stream, the current of work in process is broken up into numerous small streams, which are checked here, converge there, separate, and are liable to all sorts of eddies and cross currents. Today there may be a congestion of work at the lathes; a month hence nothing for them and a congestion somewhere else. It is, therefore, a great advantage in the interrupted flow type to be able to lay the work out in advance, so that it may be distributed as evenly as possible between possible alternative processes, so that if necessary, one order may be started a little early to get it past a prospective jam at some process, or so that night work may be arranged for before the trouble comes instead of after, or part of the work at the crowded process be sent outside for completion, or additional equipment secured, or other similar steps taken. By planning in advance we can always arrange to have a next job ready for the man before the completion of the job now in work, avoiding a very prolific source of loss in poorly run factories, the time wasted in idleness or "make-work" while the foreman is trying to think what shall be done next.

The Schedule.—The process of production control necessary to meet these needs involves four steps. First a program or *schedule* must be prepared. This involves bringing before the executive who is to decide on the program, the necessary information, first as to the jobs to be completed, date of completion, and amount or hours of work to be done at each process, and second as to available capacity, considering the jobs already scheduled to the various machines. The decision of the planning executive (who may be called production manager, schedule clerk, etc.) is embodied in a schedule or program. This schedule may be simply a list of the jobs to be completed during a given period, say a week

or month, with the order of completion, or it may involve laying out on a planning board of the time for the performance of each of the specific operations ahead of every machine in the shop for the period.

Dispatching.—The second step in production control is *dispatching*. As the time comes to start the various operations shown in the schedule, orders must be issued for their performance. This may be done by giving copies of the monthly schedule to the foremen, who are allowed to plan in their own way so long as they meet the schedule. In the more elaborate planning board systems the workman comes to the planning department window with the instruction card for the job he has finished, and a routine clerk—the dispatch clerk—goes to the machine pocket representing the man's machine on the planning board and takes off and gives to the man the job next in order in the machine schedule.

Progress Record.—Upon the completion of the operation called for, a third step becomes desirable in many cases—the keeping of a *progress record* which will show the amount of work done to date on the job.

Follow-up.—Finally, for those jobs which run into trouble, are delayed, lost, or otherwise mishandled, some sort of material tracing or *follow-up* becomes necessary. Men are, therefore, assigned who give their attention to certain groups of shop orders, checking them up by means of the progress record and taking any steps necessary to move them smoothly through to completion.

Scheduling Procedure.—The first step in scheduling—the making of general plans in advance of production—has already been referred to in the chapter on selling. The general plans for the season's output will usually be made with reference to a sales estimate showing the expected volume of business for the period. There remains the problem of detailed day-to-day control of production, since only in simple cases is it possible to translate the general schedule of the sales estimate into a day-to-day program. Usually the sales estimate schedule is

used only to guide the making of the necessary advance preparation—buildings and equipment, material, contracts, and financing. The actual working schedule is made on the basis of orders received from day to day.

The Use of Assembly Diagrams.—In Chapter V a method was described and illustrated by which the information contained in the route sheet could be put in graphic form in an assembly diagram, the time for each operation on each part, and the points of sub-assembly and assembly, being drawn on cross section paper to a scale of hours. While this diagram is not very widely used in practice (the same thing being accomplished in other ways) it gives a very clear picture of the first process of scheduling and should be clearly understood and mastered. This first process in scheduling is the making of a *job* program or schedule, showing the time at which the respective operations must be completed to finish the job on time. To arrive at the *machine* program it is necessary to take a second step, collecting from the various job programs the work for each particular machine.

Referring to Figure 45 below, A B is an assembly composed of units A and B. A passes through operation No. 1, taking 1½ days, and No. 2, taking 2½ days. B passes through operation No. 1 (same process as for A) taking 2 days, and operation No. 3 taking 3 days, while the assembly, operation No. 4, takes 3 days. If we make these assumptions and assume that the order must be completed for shipment the morning of January 15, it is perfectly clear that the latest date at which operation No. 1 on A could start would be the morning of January 7, while operation No. 1 on B would have to start at the latest on the morning of January 5. We have, therefore, in the assembly diagram the germ of a scheduling system. Systems of control essentially of this type have been used in practice, although most frequently it is not necessary to visualize the job program by means of a diagram, and we work direct from the route sheet or other primary information.

Franklin Scheduling System.—An application of the assembly diagram which interestingly illustrates the theory of scheduling is that at one time used by the Franklin Motor Company and described by Babcock in his book "Taylor System in Franklin Management." Two steps are used in scheduling and dispatching in this system. The first step is the preparation of a master schedule, which shows for several months ahead the work planned for each machine. The second step is the day-to-day dispatching of orders for work in accordance with the master schedule. The product manu-

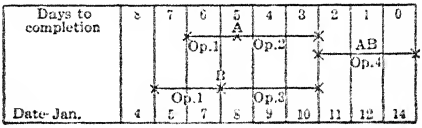

FIG. 45.

ASSEMBLY DIAGRAM.

factured was the Franklin car, a standard article but at the time this system was in use, one not made in sufficient quantities to use a flow system of production.

The master schedule was essentially an assembly diagram. As in the diagram shown in Figure 45, one horizontal line was given to each unit of product, the operations being shown in correct order, spaced apart to a scale of days just as in Figure 45. This diagram was set up on a special steel curtain grooved to hold small marker blocks, these marker blocks carrying on their face the part number, operation number and number of parts. Figure 46 illustrates a section of this board. The distance of a marker from the zero line at the right side of the board indicated the number of days before completion of a given lot of cars at which any operation would have to be started in order not to hold up subsequent operations.

A vertical ruler (see Figure 46, 5) advanced across this board

one day's space at a time would automatically indicate the jobs to be started that day. The schedule clerk each day would then get out the time cards for operations to be scheduled the next day. These cards were then placed in the appropriate pockets of a simple Taylor planning board (see Figure 48) and dispatched by means of pneumatic tubes to the machines in various shops as these machines finished the preceding jobs. Thus with the date rule set for January 16,

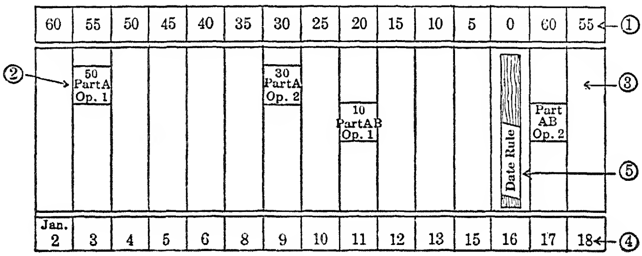

FIG. 46.

SCHEME OF THE FRANKLIN SCHEDULE BOARD.

the cards for A B, operation 2 would be taken from the file and put in the Taylor board.

An ingenious arrangement used in connection with this board made it possible to record on the operation marker, day by day, the number of parts actually completed at each operation, compared with the number scheduled. For this purpose the number of parts finished from day to day was marked in the upper portion of the marker block (see Figure 46, 2) movable type being used. To show the number scheduled to be completed a "schedule tape" (1) was placed at the top of the board. This tape was divided to the same time scale as the spaces on the board, and carried on its face a series of numbers representing the number of cars to be completed each day from the beginning to the end of the scheduled period. This tape was then advanced one space to the right each day. Suppose now that the operation 1 in Figure 46 had

been duly started January 3. To date enough parts for 50 cars have been completed as shown by the number placed in the marker. The schedule tape, however, indicates that 55 cars' requirements should have been produced, and attention will be given this item to bring it up to schedule. Operation 2, on part A, which is being fed with parts from operation 1 as completed, is up to date with 30 parts completed.

The board is arranged to carry two or more schedule periods, and the last figures of the new schedule are shown at the right of the tape. The schedule period used in the Franklin shops was two hundred and forty days, instead of the sixty-day period used for illustration.

This system is of limited practical application because of the elaborateness of the control process and consequent rigidity of the schedule. If any items should get substantially behind schedule or changes should be made in any item it might necessitate setting up the whole board again to prevent its tangling up. In practice the schedule was carefully estimated from known standard times and once established was followed practically without change, overtime, night work, and other expedients being used to keep up to schedule. The system is described as an interesting illustration which brings out clearly the two steps in scheduling, first the setting up of the job schedule on the master schedule board, then the reclassification of the elements of this schedule into a machine schedule in the Taylor board.

Reclassifying the Assembly Diagram Schedule.—Going back to the assembly diagram schedule shown in Figure 45, if we so arrange the machine capacity that each of the operations on each part could be completed say in one day, and if we made only the one article A B, we would be able to manufacture in true flow fashion. The end of the first day of operation would find a day's output ready for process number two. The second day a second lot would be ready for process two, and the first lot would have passed on to process three. With all processes filled a lot would be completed

each day, hour, minute, or other unit of time, and each preceding lot would move up one unit. After the initial proportioning of equipment, subsequent scheduling would be automatic except for proportional increases or decreases of output.

An attempt to schedule an interrupted flow type of industry by means of the assembly diagram would, however, be somewhat confusing. Here there would be a variety of diagrams for the various orders, each one showing, it is true, the proper starting date for each process, but there being no means of telling directly how many of these processes were to come to any particular machine on a given date. To schedule for interrupted flow industries it is, therefore, advisable to reclassify the information given by the assembly diagrams (or in practice their equivalents, the route sheets or time and instruction cards) bringing together by machine group all the jobs on the various orders, which are to be done on this machine. It will be noticed that this was performed in the Franklin Schedule by the shop planning board. This reclassification may be done by means of the machine control board shown in Figure 47. In this figure the job shown in Figure 45 is scheduled on the assumption that only one machine of a kind was available for each operation. To get the job done on this assumption it would be necessary, since A and B interfere at process 1, to start work on B the morning of the fourth. In actual practice the time cards from many other jobs would be coming to the various machine pockets for scheduling, and the problem of the schedule clerk would be to so arrange the jobs ahead of any one machine as to secure the most even practicable loading of each machine, consistent with getting the work done in time for the promised date of delivery for each order. If the lathe (machine No. 1) broke down, for example, the schedule clerk would try to shift the work to some other machine which was available. The schedule here shown is, of course, a theoretical one. In practice a half day or so would usually be allowed between each

process for contingencies and delays, and special markers would be hung to indicate Sundays, half days or machines out of commission.

The Machine Control Board.—The planning board is really nothing more than a means of collecting and presenting in a clear compact picture the facts as to the work ahead of each machine. It is only where the number of orders and amount of detail become too complex for unaided personal control that devices such as the planning board become necessary. The whole purpose of the planning board is to bring together all the facts about any one machine so that the schedule clerk or executive may conveniently make an

Month *January*																	Department F	
Mach. No.	Name Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	etc.		31
1	Lathe				B	B	X	A	A					X				
2	Punch Press								A	A	A							
3	Boring Mill								B	B	B							
4	Assembly						Sunday					AB	AB	Sunday	AB			
	etc.																	

Fig. 47.

MACHINE CONTROL BOARD.

intelligent decision as to order of work without overlooking any factors affecting his decision.

In Figure 47 all the operations on A B were scheduled at one stroke. Only in highly standardized industries where a very rigid schedule can be adhered to is it advisable to do this in practice. If a rush job came in, necessitating the displacement of an operation on A, all the subsequent operations would have to be adjusted, and the labor required for frequent changes of the schedule would be prohibitive. Except in well standardized cases it is, therefore, usually sufficient to schedule only one operation ahead on an order, holding subsequent operations till the completion of the preceding one.

The Taylor Planning Board.—A simple method of doing this is by the use of the Taylor Planning Board. This consists of a series of pockets, into which time cards for the various machines may be sorted, being then arranged from front to back in the sequence in which the various jobs are to be performed. Figure 48 is a drawing of a set of ten of these pockets. These sets may be built up into banks three or four deep and as long as may be necessary. Each pocket carries on the front of it a slip bearing the name or symbol of the respective machine, as 1LTA1—automatic turret lathe class 1, machine number 1, etc. Each pocket is divided, usually into two or three compartments. The drawing shows three-compartment pockets, and the front compartment (1) contains only one card, that of the job in work at the machine. Compartment two contains jobs at the machine waiting their turn, and the cards in this compartment are arranged in order of precedence. Compartment three contains jobs started somewhere in the shop but not yet ready at this machine.

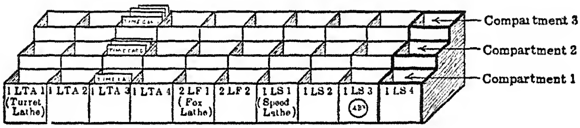

FIG. 48.
TAYLOR PLANNING BOARD.

Mention was made in Chapter IV of the possibility of making out a complete set of time or instruction cards by simply copying the various operations from the route sheet. Using the Taylor board these cards will be held in a reserve file until the material is delivered at the first machine for operation. If the first operation is at lathe No. 1, the instruction card will then be placed in pocket No. 2 of Figure 48, "work ready for machine," where it will be slipped in behind any other job cards waiting their turn at the machine. As

the machine starts operation, the front card in pocket number two will be taken out and given to the workman, a duplicate being detached and placed in the front pocket, number one, "jobs in work."

All the cards for later operations on the order will now be distributed to the various pockets of the proper machines, being placed in the pocket number three, "jobs not ready for machine." No attempt is made to keep these "not ready" jobs scheduled in any definite order, although if desired it is easy to see at any time how much work there is in the shop altogether, ahead of any machine. But as fast as preceding operations are completed on a job and the job is delivered at a given machine, the proper job card will be taken out of the third pocket and moved to the second pocket. Normally it will be the last job to be done, and will be put back of the other tickets, but if it bears a "rush" sticker or is otherwise marked urgent, it may be moved ahead of other jobs as the situation demands.

This provides a very flexible method of keeping track of and scheduling jobs. After a decision is made, the physical change of schedule is simply a matter of rearranging a handful of job order cards. The Taylor board may either be used centrally, all the machine pockets for a large number of machines being in one central planning office, or it may be broken into sections, each foreman taking care of his own boxes. An even simpler file is a card index, with dividers for each machine, jobs being slipped behind the divider for "lathe number one," etc., as received.

With the Taylor board, machines out of commission or operators absent may be indicated by appropriate markers hung on hooks on the front panel of each pocket. The degree of detail in arranging cards, use of markers, etc., will depend somewhat on the number of machines the operator must watch. If there are only a few machines, the record kept on the board may be correspondingly simplified.

It is interesting to notice that instead of using a board for

graphically collecting and classifying according to machine, the various jobs ahead of each machine, it is practicable to keep a numerical record of hours of work or loading for each machine. As jobs came in calling for a certain number of hours of work at a particular machine, this time would be added to the work already ahead of the machine, carrying the loading ahead say from July 15 to August 5. If one of the jobs scheduled took substantially longer than the schedule time, evidently the delay would have to be added, carrying the schedule forward a proportionate amount. A system of this nature was in use at the Hog Island Shipyards, time cards for the various machines being automatically sorted and totaled to machine number by tabulating machines and posted to the records of machine loadings.

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CHAPTER XII

SCHEDULING

The general scheme of scheduling, as described in the previous chapter, is first the analysis of the job into operations and the decision from unit time data as to the necessary starting date for each job. A second step then necessary in scheduling for an intermittent industry, is the re-classification by some form of planning board, of these various jobs and their collection to the respective machines so that an intelligent program or schedule can be made for each machine.

Progress Records.—Wherever the number of jobs which must be kept track of in the shop is large, some method of systematically recording the progress and present location of the job becomes necessary. With the time cards for the various jobs distributed around more or less irregularly among the hundred or more machines controlled by the planning board, it would be very hard to locate the job if information was wanted as to how far along it was, in order to give information to the customer, to make sure the job was progressing according to schedule, that it had not been lost, or that parts had not been spoiled and would have to be replaced. The job could be located by going back to the route sheet or assembly diagram and tracing it up through each operation until it was found, but it is more convenient to keep some form of progress record which checks each operation as finished, and which shows exactly the location of the job and may also contain other information as to spoilage, causes of delay, etc.

A very simple and inexpensive form of progress record may be furnished by the job cost sheet, where, as is often the case,

costs are compiled by a division of the planning department. Where these sheets can be kept available in the planning department, and where prompt posting of the costs taken from the requisitions for material and the time cards may be relied upon, these cost sheets should give without extra clerical labor an up-to-date history of the job, which would show to within a day the location of the job and could also contain columns for record of spoilage at each process, etc. A practical objection which frequently prevents such use of the cost sheets, however, is that it is difficult to keep the posting continuously up to date, in fact it may sometimes only be done monthly or at periodical intervals, the time cards and requisitions being totaled on an adding machine and only the totals used. It is, however, entirely practical and effective where this objection can be met.

A second method of keeping the record in an intermittent industry where route sheets would be used is to provide spaces for posting and checking the progress of one or several orders in columns at the side of the standard routing, so that as the material listed in the bill of material is received, item by item, and the operations are reported finished, the completion of each may be shown by drawing a line or preferably using a date stamp opposite the corresponding space on the route. This type of progress record is illustrated in Figure 21, Chapter V.

An Illustrative System.—An interesting variation of this idea was used by the manufacturer of a rather complicated office device. Unit parts, sub-assemblies, and finished machines were carried in stock. A combination stock record and follow-up board, consisting of a number of panels about two by three feet and hinged in a vertical display frame, like the leaves of a book, was used. Each of these panels held a series of slots running horizontally across its face, into which could be slipped strips of paper, one strip for each unit part or element carried in stock. One or two panels would thus contain a complete list, represented by this series of

horizontal strips, of the parts for a major assembly group. One of these panels is reproduced below in part, for a "rocker pin" in which four operations were necessary, Figure 49. The two, or usually more, series of digits at the left indicate the quantities in stock of the particular part. Sliding over them in the grooves of the slot are spring wire markers whose positions mark particular digits. The markers shown indicate ninety-eight parts in stock. The minimum for the part is 100, so an order has been issued, and the marker at the right indi-

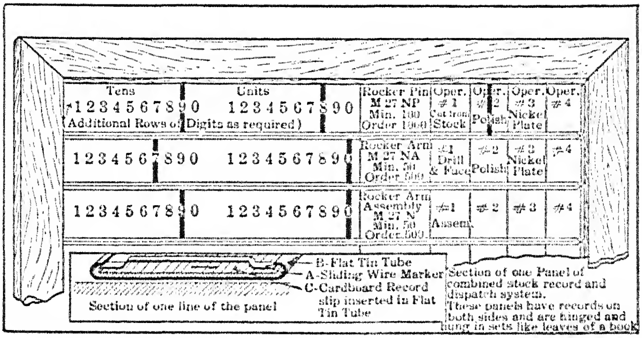

FIG. 49.

COMBINED STOCK AND PROGRESS RECORD.

cates that the job was progressed as far as operation No. 2. The schedule clerk makes the adjustments on the board as stock is withdrawn or as operations are completed, automatically issuing a replenishment order when the minimum stock is reached.

A standard route sheet for each part is printed on an instruction card filed by part number. As the order for replenishment is issued, the proper instruction card is taken out and filed in a simple tickler file, being classified by machine as in the Taylor planning board. Thus for the first operation it would be filed under the automatic lathe group index card in the tickler. As the lathe man comes to the

window for more work, when this card reaches its turn at the front he would be allowed to read it, would be given a time card bearing the job or lot number, and told at what previous machine to find the work (there being no special material handling system necessary in this small shop).

The operation would then be checked by moving the wire marker on the proper line in the panel, and the standard instruction card would be transferred in the file to the machine which was to perform the next operation.

Description - *Connecting Rod*
Ship to - *Jones* Part No. - *27 A 2*
Shipping date - *10/1/22* No. in lot - *1000*

Requirements				Operation 1				Operation 2				Etc.
Date	Order No.	Amt.	Total	Date	No. Recd.	No. Finished	Scrap	Date	No. Recd.	No. Finished	Scrap	
10/1	*A-6*	*1000*	*1000*	*10/15*	*1000*			*11/3*	*641*			
				10/3		*641*	*9*	*11/4*		*630*	*11*	
				10/5		*300*	*5*	*11/5*	*300*			
				10/6		*45*		*11/6*	*45*			
								11/9		*300*		
						986	*14*					

FIG. 50.
PROGRESS RECORD FOR "SPLIT" LOTS.

Care would have to be taken in the mechanical construction of the panel so that markers would not slip or fall out, but with this provision the system would provide a very compact control machinery for the small plant in which it was used. It was easily kept up by one man.

In the intermittent and special order industry an effort is frequently made to keep all the material composing a lot together, one operation being completed before the next is started, as this greatly simplifies the record work and control, particularly with a large number of small special lots. As the lots become larger and fewer and the industry inclines toward the repetitive type, it is commonly advantageous to break up the lot so that it is simultaneously in

process at several machines. A slightly different progress record becomes desirable here, which provides space for entry of successive parts of the lot, as in Figure 50 above. The record shows operation 1 completed with 14 scrap, 930 good completed at operation 2 with 11 scrap so far and a balance of 45 to be finished. This would be continued for as many operations as there were on the part. It would in some cases be possible to make this serve also as a cost record by providing an additional column in each operation for the posting

PROGRESS RECORD — Part No.

Name of part — Order No.

Date	Operation 1			Operation 2			Operation 3			Operation 4			Operation 5		
19	Standard	Actual		Standard	Actual		Standard	Actual		Standard	Actual		Standard	Actual	
Jan.	Output	Day's	Total	Output	Day's	Total	Output	Day's	Total	Output	Day's	Total	Output	Day's	Total
4	4	3	3												
5	8	5	8												
7	12	4	12												
8	16														
9															
29															
30															
31															

FIG. 51.

GANTT'S "GRAPHICAL DAILY BALANCE."

of labor costs, and a space at the left for entry of material costs from requisitions. The "Requirements" column is used for apportioning to the part, as in a stock record, the requirements of the various customers' orders as received. When sufficient of these had accumulated a manufacturing order would be issued.

The Gantt Chart.—One of the earliest published types of progress record was that described by H. L. Gantt in his paper before the American Society of Mechanical Engineers, entitled "A Graphical Daily Balance of Manufacture." The principle of the key record of this plan is shown in Figure 51. In this record, entry was made at the beginning of the job of

the number to be delivered complete each day, and the actual day's output was posted opposite this figure, giving a standard schedule for comparison with the actual record of progress. This method has been developed and elaborated upon, and Wallace Clark, in his book, "The Gantt Chart," describes the details of its use and its various applications. Essentially the system is to establish a standard hourly or daily rate of production, and to represent by horizontal lines drawn to scale on a sheet of cross section paper, both the time elapsed and the standard quantity of output scheduled for this time.

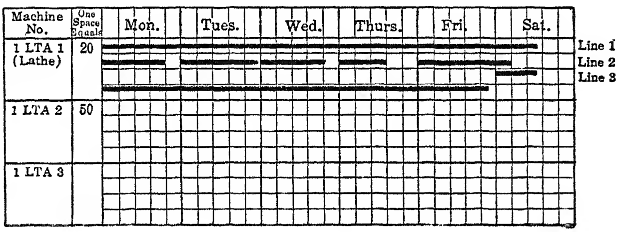

FIG. 52.

THE GANTT CHART.

Thus, in Figure 52, modeled after Clark's illustration, the light line number 1 shows a scheduled unit production of one hundred for each day except Saturday, when fifty were scheduled. Line number 2 shows each day's actual output, 80 on Monday, 100 on Tuesday, 80 on Wednesday, 60 on Thursday, 120 on Friday, 50 on Saturday. Line number 3 shows the cumulative total of each day's output, and by comparison with line 1 shows the actual as compared to the scheduled production to date. Several machines or departments may be thus represented, one below the other, on a single sheet of paper, the graphic scale of output varying as may be necessary with each unit. Thus one of the small spaces represents an output of 20 for lathe 1LTA1. It might represent 50 or any other figure for another machine, such as 1LTA2.

In the completion of large jobs extending over several

weeks or months, such as building ships, large buildings, grading and excavation, etc., a special problem of progress record keeping arises. Provision is often made with work of this class for payments on account at certain percentage stages of completion, as an aid to the contractor in financing. Cost records, photographs of the job, records of yardage of excavating, tonnage of steel used, are here employed in forms adapted to the special information required.

Follow-Up.—So far our discussion of the control of operations has covered principally the building up of a system by which the various steps are taken in a more or less automatic and routine fashion. The order comes in, operation completion times are estimated, time and instruction cards are written and sorted out to machine, and at each machine the order of work is decided upon by the schedule clerk. The schedule clerk of course decides this order with reference to the shipping dates of the various jobs, but he is likely to have too many jobs to handle to be able to carry all of them in his mind. In other words, he sees the situation primarily in terms of machine programs, not of customer's programs. Some one is needed who will give each job the necessary personal attention to prevent it from becoming stalled or overlooked. If the time card should be lost or misplaced it might be weeks before the loss of it would come to the attention of the schedule clerk. The work of the schedule clerk and of the other members of the planning department is primarily functional, and as in most functional organizations, some coordinating, cross-checking agency is needful to take care of cases which slip out of the regular routine and get stranded.

To secure this coordination a man or group of men is usually provided whose work it is to periodically check up on each order in the shop and make sure that it is proceeding properly. These men are variously known as "follow-up" men, material "tracers," "chasers," or "ticklers." Usually the work is so divided among them that one man takes charge of all orders from a certain class of customers, or for a cer-

tain class of goods, and is personally responsible for moving his orders through on schedule and without loss of material.

There are two plans for the follow-up of orders. The more thorough but also the more costly plan is to follow up every order at regular intervals whether it is moving satisfactorily or not. Under this plan the tracer is given a copy of the order as it has been started. He then locates the job with the aid of the progress record and checks it up to see that it is properly under way, that all material has been delivered, and that no tools are lacking. Then he decides on the next date at which the order should have attention, say ten days, and puts his copy of the order in a tickler file to come up for attention ten days hence. In this way he keeps track of it till it is finally shipped. Some orders will take almost continuous attention, others little if any. The material tracer will confer with the schedule clerk as to the order of work necessary at the various machines, to get his jobs through. There will at times be conflicts between various tracers when urgent jobs happen to meet at the same congested machine, and the schedule clerk acts as arbiter and judge in such cases, making an impartial decision in view of the facts as presented.

A daily morning meeting, attended by the material tracers, the schedule clerk, superintendent, and the foreman of any departments which happened at the time to be congested was found to be a helpful means of adjusting difficult cases to the best advantage. Everyone left this meeting with a clear idea of the day's program and points of difficulty.

A second plan of follow-up which involves less work than this one, where it can be used, is to give attention only to those jobs which are giving trouble. If, for example, the time cards are stamped with a scheduled completion date, the dispatch clerk who receives the completed time cards can be instructed to sort out and give to the tracers only those cards which are behind schedule, the majority of the jobs going through without the necessity of any special attention.

For most effective control of production a proper balance

must obtain between scheduling and follow-up. Weak scheduling means excessive follow-up in an effort to remedy the trouble, and a constant badgering of foremen and increase of costs for "personally conducting" jobs. The confusion becomes cumulative, the whole schedule gradually becoming so delayed that personal attention is needed on nearly every job.

Centralization.—One question of practical importance in the laying out of a system of production control is as to the degree to which it is desirable to centralize this control. In the Franklin System to which reference has been made, the entire control of a shop having hundreds of machines housed in quite widely separated departments was concentrated in one central department and every change of work of every machine was controlled directly from this point.

With a system of this sort properly administered we would expect to find a high degree of coördination, since the schedule clerk works with a map of the whole situation spread out before him and will be aware of conditions in other departments, congestions, or future available capacities, of which the local foreman knows nothing. By bringing all the clerical work together in one office it becomes possible, too, to effect a considerable saving through functionalization and the application of mass production methods to the clerical work. Time cards can be quickly and economically written by routine clerks aided by duplicating devices, instead of being prepared intermittently one or two at a time by an expensive foreman who is incidentally a poor clerk, and who has many other things to distract him. Scheduling, dispatching, posting of progress records, checking of time, follow-up, become specialized functions more quickly and accurately performed because they are done in volume at one central point. Less clerical labor is also required because the peak demands of the various sections of the shop tend to come at different times and thus to neutralize each other and produce a better load factor.

On the other hand we should expect, from the theory of centralization, certain serious disadvantages in the plan of

bringing all production control to one point. Control is more remote and less personal. Many decisions must be made by or at least passed through the hands of cheap clerks who are not capable of the intelligent decisions of the foremen on the job. The impromptu adjustments by which a foreman shifts the load from a disabled machine and improvises a makeshift are not easily made by a schedule clerk to whom each machine is but one of hundreds of units, thought of in terms of time.

More communication and travel and red tape are also necessary with the centralized plan. There must be written orders and signatures to fix a divided responsibility. Each item must be handled by many men instead of by one man, each man in the chain must take the mental effort necessary to grasp at least part of the circumstances of the order. If trouble comes there is not the same elasticity. A breakdown in the work of the schedule clerk, or the tracers, or of any essential element ties up the whole shop instead of being limited to one department. The office organization as a working unit comprises perhaps ten or twenty essential men instead of two or three, and is consequently not as easy to cut down in slack times or expand with sudden increases of business.

For all these reasons, and above all because it becomes physically impossible, even with the best planning boards and other visualizing devices, for one man adequately to handle more than a certain volume of detail, we seldom find scheduling as highly centralized as in the Franklin plant.

Decentralization.—The commonest device used to break up and decentralize scheduling while still retaining control is the setting of a dependent sequence of delivery dates. The order passes first through the usual stages of analysis by a central planning department, operation layouts are prepared if not already available and the amount of work for each department is estimated. In this central office some form of loading record, showing the volume of work ahead of each

machine, or more usually of each department in total, will often be kept which will make it possible to estimate the approximate date at which work in each department can be completed. A shipping date is set, either with reference to this estimate or in urgent cases to the customer's need or salesman's promise. The order is then issued to the last processing department, say the assembly department. The assembly foreman or his department clerk proceeds to schedule in detail the machine sequences necessary to meet the date set, and sets a new date at which the material must come to the department from the previous process, say the unit part departments. Copies of the order with this new date opposite the respective items are then sent to the various originating departments, and each of these in turn arranges his schedule any way he pleases, and changes it as often as he likes, so long as he meets his delivery dates with a proper degree of manufacturing economy. If desired, one foreman might use a Taylor type planning board, another might rely on memory, as to their sections of the work, although a uniform system, such as a date tickler file for starting jobs, would usually be provided for each by the management.

If the foreman finds that he is going to be unable to meet a date set, he is responsible for reporting immediately, when the schedule is received, or as soon as the trouble is discovered, to the central office. A follow-up man will then get on the job, and will find out whether the assembly department has provided leeway sufficient to absorb the delay, or he will correct the difficulty by securing material, etc., or will notify the office that the date cannot be met. The office is then in a position to revise the schedule and notify the customer in advance as to the expected delay.

There is no theoretical limit to the extent to which this subdivision and decentralization may be carried in a large organization. The process is very similar to that by which the general policy decisions of the chief executive of a business are broken up into more and more detailed orders by

successive subordinates, each subordinate acting within the general limits of the order which comes to him, and detailing and contracting the range of independence for those under him.

Such a system evidently greatly reduces the amount of communication necessary between foreman and central office, and makes for flexibility of adjustment. On the other hand, it multiplies the number of independent agencies affecting the order, and a greater margin for delays must be provided in the way of longer dates, more reserve equipment, etc. But because of its greater simplicity and flexibility it is probably the predominant type of control in large business of lot repetitive and special order nature.

A balance may evidently be struck for any particular case, between the cost in increased clerical expense, of accurate and detailed control, and its savings over a more approximate system, in the way of more rapid movement of materials with consequent reduction of working capital, and in the way of reduction of equipment, certainty of delivery dates, etc.

We have been somewhat presupposing in this discussion a fairly accurate knowledge by the planning department of operation times. Very often this knowledge is not in the possession of the management, and frequently, with constantly changing work, it is hardly worth getting in full detail. In this very common situation the simpler and more approximate methods must perforce be adopted. In such cases the delivery date schedule for the order is little more than a reasonable hope expressed to the customer, and scheduling is confined to keeping the work passing through the machines in approximately the right order, by some such device as the Taylor planning board. A good guess is made as to the shipping date and everybody tries to meet it, using overtime, purchasing of parts, or using other emergency measures when justified and necessary.

The more refined and elaborate devices of control to which reference has been made can be looked for only where a

considerable degree of standardization of process and time is possible and profitable. And in this case the industry can often develop toward a repetitive system in which the central mechanism becomes relatively simple, as happened in the case of the Franklin Motor Company.

Requirements of a Scheduling System.—In the interrupted flow type of industry, the things which should be required of any good system are (1) that it shall keep the machine and man constantly at work as long as there is work ahead of the machine, (2) that it shall pass the jobs through the machine in the right relative order, and (3) that its follow-up mechanism shall be adequate to get derailed or lost jobs promptly back on the track. Full scheduling in the sense of predicting accurately the time of completion of the job and of its successive operations, is desirable and makes for smoothness of operation where possible and not too costly. But in most shops there are of necessity such sudden jumps of production—emergency orders, cancellations, new models, etc.—that a complete schedule is an impossibility, however desirable it might be.

Scheduling is very closely involved with the theory of centralization and in fact most of the devices of control, such as the machine control board, and other schedule systems are essentially only methods of aiding the executive in his decision by giving him a clear picture of facts.

In the attempt to keep the work within the bounds of one man's capacity the rule for the extent of centralization necessary in any particular case becomes of interest. This rule is that in general a decision need be carried only sufficiently far up the line from local point to central head, so that the executive deciding and making the plan has a grasp of all the essential facts of the situation. In a plant making only one assembly it would be difficult for any single department foreman to have this grasp of essential facts. He does not know how many processes must follow his or how long they will take, and while he may schedule excellently as

regards economy of changes of set-up on his machines, his plans will not coordinate with those of other departments unless he works within limits set by a central department which sees the whole situation.

On the other hand, the occasion once came to the writer, of reviewing a proposed centralized scheduling system for a repair shop consisting of a number of practically independent departments—a tin shop, foundry, machine shop, blacksmith shop, etc. Sometimes a job would involve more than one department, but usually not. The attempt to control the machines in each of these departments from a central planning office, beyond a simple record of orders and promised dates of delivery, would have involved a clerical work and complexity which was wholly unnecessary, since each foreman, without any planning board, was in possession of all the facts necessary to scheduling, and perfectly competent to exercise a more accurate control over his work than the central department could have secured.

CHAPTER XIII

TYPICAL PLANS OF PRODUCTION CONTROL

THE purpose of this chapter will be the brief description of several typical systems to show how the elements of control separately discussed in previous chapters are combined into actual working systems.

Plan No. 1: Flow Repetitive.—Manufacture of automobiles. A general sales estimate and month-to-month output program are made up each season as a basis for financing, purchasing new equipment, and similar preparations. Day-to-day orders are issued a few days in advance on the basis of cars sold to dealers, a small reserve stock being held to take up minor fluctuations. The plant receives its parts from a parent factory and assembles only. Each department must deliver to the final assembly track, and the department foreman will adjust his force by hiring new men, by short time, etc., as may be necessary. A certain volume of repair parts, etc., must be put through, so that the actual schedule for any foreman will include not only parts for the day's assembly, but a varying amount for repairs. Evidently, the repair part work can be used to a limited extent to compensate for daily fluctuations in sales. The plant does not, however, make a policy of carrying more than a few days' supply either of repair parts or of unit parts for assembly. The work of follow-up by purchasing and traffic departments, to keep material coming in uniformly as needed, is very important. Because of the close margins within which inventory is maintained, accurate follow-up is necessary to keep each unit department in step, to prevent a department (for example, the wind-shield assembly line) from either falling behind and

tying up the final assembly track, or from piling up too large a stock before needed for production.

This is typical of flow repetitive control methods. Most of the scheduling is done once for all in the laying out and initial proportioning of the capacity of the various departments. With the minor exception of repair parts, capacity is expanded or reduced as a whole and kept in accordance with the current schedule of orders. Accurate follow-up is needed to secure accurate supply of materials and to keep the various departments in step. Little is needed in the way of lot identification or other than automatic movement of material, or in performance instructions to workmen.

Plan No. 2: Modified Flow Repetitive.—Men's Garment Industry. In this industry orders for suits are taken by salesmen some time in advance of production, the incoming orders being analyzed as described in Chapter IV, so that all orders for one model of suit and style of cloth are collected together. These individual orders are then from time to time gone over and grouped into manufacturing lots containing enough suits of one kind to permit of economical cutting and manufacture. Instruction cards are prepared as described in Chapter IV.

It is a characteristic of the tailoring industry that the general movement of work through the various processes is practically standard, the garment moving in regular order from one shop section to the next, up to its completion and delivery to the shipping floor. There is therefore no problem of control of direction of movement in this case, nor any special need for individual scheduling of producing units. There is, however, the usual tendency of section foremen, or heads as they are called, to put through first the large lots on which volume of output can be obtained, and to neglect small, fussy, or delayed lots. There is also a tendency to allow garments to accumulate in the section, slowing up production in following sections and increasing the average inventory of work in process.

To remedy these difficulties and to give a control of pro-

duction, what is known as the *block* system of scheduling is in common use in the garment industry, and in fact finds application in many other fields such as the scheduling of order filling in the large mail order houses. In this system approximately enough work to absorb the capacity of a particular section for say a half day is grouped together into a block, virtually a multiple order. A standard schedule is adopted, the first department being allowed half a day, the second a day, the third a half day, and so on progressively from the starting time of the block, to complete the block and move it on to the next section. A clerk in each section notes the numbers of the various orders composing the block, as it is received, noting also the date, and as each item is delivered to the next section, credits the first section by stamping the date of delivery opposite the item in the record. Thus this system of debits and credits carries the garment through the entire section. A follow-up of the work of the sections is obtained by sending a boy through the factory every day, to make a record of the number of blocks still remaining in the section. No block is considered cleared until every order in the block is out of the section, and no block is cleared, if any preceding block still remains in the section. Thus a strong pressure is put on the section heads to move work through the section rapidly and in the order in which it is received. The section head is at liberty to get as far ahead of schedule on any particular block as he pleases, but a record is made of the blocks on which he is behind from day to day, and used in determining the efficiency of the section head.

This industry bears many similarities as regards the orderly movement of work in successive waves through the factory, to the situation described by Babcock as existing in the Franklin Motor factory, and it is interesting to notice that a simplified adaptation of the Franklin schedule board, employing a moving tape to indicate the scheduled progress of work through the factory, has been successfully worked out in one clothing factory.

Plan No. 3: Simple Variety Repetitive.—Household electric utensils. In this shop, manufacturing flat-irons, etc., stock was carried of all unit parts and sub-assemblies with a maximum-minimum control. As stocks were drawn down to the minimum, the storekeeper wrote a manufacturing order, and each day the superintendent gave to the various foremen the previous day's accumulation of orders, using his judgment in making up advance stock, where needed to keep a department busy, and acting in conference with the general and sales manager in revising the stock limits upward or downward as demand increased or when supply of any particular material became uncertain. Most of the work in this plant was assembly, very quickly taught to new help and requiring little equipment, so that sudden fluctuations could be met with little expense. No attempt was made at time scheduling and none was necessary.

Plan No. 4: Modified Repetitive.—Automobile motor industry. This company manufactured motors to order, in lots varying from one to several hundred. It also sold standard pattern motors, made up along with the special orders, for which unit parts and assemblies were carried in stock. It also had to carry a limited stock of repair parts for a wide variety of customers' designs. Control was centered in a combined production and stores department, orders for stock motors and repairs being issued by the stock record clerk by the usual maximum-minimum plan. A monthly schedule of orders to be shipped, listed in proper order of completion, was furnished this production department by the sales department. This order, calling for say twenty to fifty lots of complete motors of various types, was detailed by means of a parts list or bill of materials for the various motors and the detailed quantities of each item were posted to a requirements column on the combined stock and progress record of each part. A form similar to Figure 50, Chapter XII, was used. Monthly orders were issued to each foreman, calling for the proper requirements of parts to be made by the

Copies to: ....Dept.
........Dept.
SHIPPING LIST FOR MONTH OF................19... ....Dept.

Notify scheduling department at once if any item cannot be delivered as scheduled.

Shipping date	*Order No.*	*Quantity*	*Item*	*Customer*
Week ending Jan. 6...	27413	400	Model 27	Jones & Smith, Ft. Wayne, Ind.
	27414	150	27	Central Supply Co., Palo, Ark.
	26702	224	27	Acme Co., Pittsford, Mass.
Jan. 13..	27415	20	35	General Supply Co., Akron, O.
	27425	100	27	R. W. Brown, Houston, Tex.
	27440	200	28	Walker & Co., City.
	27441	90	28	R. F. Purce, Muncie, Ind.
	26990	400	10	Tryon Co., City.
Jan. 20..	27413	400	27	Jones & Smith, Ft. Wayne, Ind.
	27461	10	27	City of Maine, O.
	27462	200	28	Ryan Mfg. Co., Des Moines, Ia.
Jan. 27..	27480	250	27	Elkhart Bldg. Co., Elkhart, Ind.
	27482	200	27	Automatic Mach. Co., City.
	27484	200	27	C. H. Wedge, South Bend, Ind.

Signed ....

FIG. 53.

SIMPLE FORM OF SCHEDULE SUITABLE FOR LOT REPETITIVE OR FLOW TYPE OF INDUSTRY.

department (Figure 53). Finished parts were sent by the foreman to the stores department, such receipts being posted against the requirements. A periodical report was made to the superintendent of parts behind schedule, as a basis for follow-up work and executive pressure on the delaying department. In accordance with the monthly schedule the stores department got together each day from stock the unit parts required for the next day's assembly, and a daily order was issued to the assembly department for the orders to be completed next day. A special follow-up man took charge of seeing that service and repair parts were

promptly drawn from stock and forwarded, or made up if not in stock. Such repairs were added to the "requirements" column and to the foreman's orders.

Since all the processes on a motor with a few exceptions vary only in detail from one job to another, the output in motors per month was pretty accurately known, and the principal problem was to watch and control the departments initiating the unit parts, to see that jobs were started in the right order and that the required volume of output was maintained.

Plan No. 5: Stub-Tag System.—Metal furniture. In the manufacture of metal furniture, principally beds, patterns are standard but quite numerous, and unit parts are carried in stock and controlled in the usual way by maximum and minimum stock limits. Articles are assembled as orders are received from the customer, a small margin of finished stock being maintained. The various articles are divided into groups, the general routing and time required for the completion of any one of the articles in a group being practically the same. Thus group one would include articles requiring one day for completion, group two, articles requiring two days and so forth. This gives a very simple method of scheduling the time required.

As each order is received by the factory, a tag is made out and attached to the lot, bearing the identifying lot number, description, number of parts, etc., on the body of this tag. Attached to the body is a series of perforated stubs, which may be torn off one by one. (See Figure 22, Chapter V.) Of these the first or bottom stub serves as an office tickler and progress record on the job. The second stub is a material requisition calling for the proper quantities of materials. The next stub calls for the first operation and is torn off by the operator, signed by the inspector, and turned in by the man daily as his record of piecework earnings. Each succeeding stub calls for another operation. Each stub bears the required date of completion of the operation and the order

number. The tag itself remains attached to the lot permanently for identification. As the stubs showing completion of the various operations are received at the office, they are sorted at once into operations completed on time, and those late. The stubs on time go without further attention to the timekeeper, but the late stubs are given to the material chaser, who brings pressure to bear, as may be necessary, on subsequent operations, in order to ship the article on time. Thus, much follow-up work is eliminated by this simple application of the exception principle. The last stub of the tag serves as the factory's record or manifest of completion and shipment of the order. The office tickler stub is filed for reference until the order is completed. If desired, this stub could contain spaces for marking operations completed, or, following another plan, could be moved from compartment to compartment as operations were completed, in a rack having a compartment for each operation number.

No record of work ahead of each machine is kept with this system, but this plant, in common with many other industries, requires mainly assembly benches or simple machinery for the assembling process. This equipment is not costly, and it is cheaper to supply enough of it to meet all possible demands than to attempt to obtain a higher factor of use for it by elaborate scheduling. Workmen are sufficiently skilled to perform the necessary variety of operations, being shifted from one job to another as needed.

Plan No. 6: Decentralized Variety Repetitive.—Electric Manufacturing Company. The company manufactures a great variety of lines, and individual orders frequently call for a large installation, such as a municipal power plant with turbo-generator, switchboards, connections, etc., complete. On account of the size of the business the method of decentralization described in Chapter XII is used. To keep track of the order and coordinate the work of the various departments, the order is given to a *correspondent* as soon as it is received and this correspondent takes charge of the order, handles

relations with the customer, supervises the engineering work and the follow-up of manufacturing processes. Each correspondent specializes on one class of work. One will handle municipal, another hydro-electric, another railway jobs. The bills of material prepared by the engineering department go to the stores department, which, theoretically, carries everything in stock. Practically, many of these items will have to be manufactured to order, and for each of these items the stores department will issue a manufacturing order covering one lot of items of a kind only. This order will be dated for final delivery in accordance with instructions from the correspondent, a proper allowance being made for time for packing and shipping so as to meet the customer's date of promised delivery. The stores department thus acts as a clearing house for all orders. By thus clearing all orders through the one department, duplication of orders, or the manufacture of parts already in stock, is prevented. The stores department thus becomes in a sense the sole customer of the shop. Stock orders to replenish items normally carried will be issued also by the stores department on the manufacturing department, as minimum stock limits are reached for the various items.

These dated orders go to the general foreman of the assembly department, and are arranged by his department production clerk with reference to his available machine capacity and to meeting the shipping date, with some allowance for contingencies. A copy of the order is filed in a date tickler file to come up and be started at the proper date according to this schedule.

As described in Chapter XII, the assembly department now issues orders on the unit departments with reference to its starting dates and the production clerk in each department in turn schedules and issues suborders if needed. All these orders bear the same shop order number and the correspondent is notified of this number so that he can readily make inquiries as to progress, or through the stores department can

follow up and secure action on any order which is urgent or delayed.

Plan No. 7: Taylor System, Car Building.—Lot repetitive or special order, with a large variety of parts or number of orders. The description of this system will serve as a recapitulation of the various steps taken in the Taylor planning system to which reference has already been made. On account of the wide variety and frequent change of orders no attempt was made to schedule detailed operations to specific dates, scheduling being limited to a control of sequence. The steps in control may be divided into two general stages—first, preparation of paper work, the necessary orders, route sheets, checking of material, etc., and second, scheduling or the day-to-day control of work.

In the first stage of preparation of the order the following steps were taken. As the order was received a shop order was written in triplicate, giving the order number, part number and description, with spaces on the various copies for checking progress, etc. One copy of this shop order was later filed by order number for reference, a second copy was filed by part number, these two giving a cross index for locating any order easily. The third copy was given to the follow-up man and used by him as a memorandum in keeping track of subsequent progress.

The shop order next went to a material detailer, who from blue prints or standard bills of material on file prepared a list of all materials needed. This list, after serving as a check list for filling requisitions, was used as a material cost record, material cost being extended on the requisition and posted to the list.

Material requisitions (Figure 43) and identification tags were also written at this point for each item of material on the list. The material list was now sent to the stock record clerk, who apportioned or reserved for the order the amount called for of each item of castings, etc., ordering from the purchasing department if any items were not in stock, and

checking off as in stock or not in stock each item on the material list mentioned.

The order was next sent to one of the route clerks, who ascertained whether or not standard route sheets (like Figure 21, Chapter V) were available for the order. If the job was a new one, a route sheet was prepared and filed; if not, a job heading was started on an existing sheet for checking the

<table>
<tr><td>Ret'd
Issued</td><td colspan="4">(Time stamp here)</td><td colspan="3">Charge
to
Job No.</td></tr>
<tr><td colspan="5">Man's Name ____________</td><td colspan="3">No. ________</td></tr>
<tr><td>Mach.</td><td colspan="2">Location</td><td colspan="2">Dwg. No.</td><td colspan="3">Job is { Finished
Not Fin.</td></tr>
<tr><td colspan="5" rowspan="4">Instructions:
____
____________</td><td>Original
No. Pieces</td><td colspan="2"></td></tr>
<tr><td>No. Pieces
Unfinished</td><td colspan="2"></td></tr>
<tr><td>No. Pcs.
Fin. to-day</td><td colspan="2"></td></tr>
<tr><td>No. Pcs.
still to do</td><td colspan="2"></td></tr>
<tr><td colspan="3">Machine</td><td colspan="2">Man's</td><td rowspan="2">Rate per</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Time</td><td>Rate</td><td>Cost</td><td>Time</td><td>Rate</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>Earnings
To-day</td><td></td><td></td></tr>
<tr><td colspan="5">Checked</td><td colspan="3" rowspan="3">Day
Piece } Work Card</td></tr>
<tr><td>Route
Sheet</td><td>Pay
Roll</td><td>Mach.
Record</td><td>Cost</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
</table>

FIG. 54.

TIME AND INSTRUCTION CARD.

progress on the order. This route sheet was then turned over to clerks who prepared from it a time card for each operation (Figure 54), and move card (Figure 55) for use as described in Chapter XI for control of movement of work by the planning department. Time and move cards were clipped together and filed away by order number to be ready when needed. With the completion of this step, all the working documents were prepared and the order awaited only the arrival of any lacking material to start work.

Meanwhile the material tracer who is going to have charge

of the order has received at the very first step his tracer copy of the shop order, and has dated it ahead in his tickler file for about the time when the clerical work should be completed, so that he can take action if it is unduly delayed. The requisitions and the list of materials, checked as to items in stock, are also sent to him by the stock record clerk, who later reports to him the receipt of the lacking items as they come in. The tracer checks off these items on his list of ma-

Move Card			Charge to Job No.		
No. Pieces ____			Piece Symbol ____		
Description ____					
Operation No.	Standard Machine	Loca- tion	Signed, Moveman	Signed, Foreman	
	Stores				
1					
2					
3					
4					
5					
6					
7					

Fig. 55.

MATERIAL MOVE ORDER.

terials and when all are in stock he draws the move card from the waiting file and sends it out with the requisitions to the storeroom, where the material will be delivered and signed for by the move man and delivered by him to the foreman. The move card is now returned to the office, and an assistant to the schedule clerk checks the operation on the route sheet as started, and draws the time cards for the job from the waiting file. The move card is clipped back of the first operation time card and the two are put into a pocket for the attention of the schedule clerk, who will place the ticket in its proper order (normally last) in the second pocket, "work ready for

machine," of the proper machine box on the Taylor type planning board, which is like that shown in Figure 48, Chapter XI. The time card is made in three copies and at this point one copy is detached and sent to the foreman concerned as a notification to get tools, etc., ready for the job. The assistant then distributes the remaining time cards for subsequent operations to the third or reserve pockets of the various machines, whence they will be moved to the second pocket as the work progresses.

The material is now at the machine and the job is waiting its turn for operation. When previous jobs are completed, the workman, coming to the planning department for a new job, will be given one of the two remaining copies of the time card with his starting time stamped on it. The other copy will be moved forward, with the move card clipped to it, into the first machine pocket, "work in process at the machine." When this job is finished the stopping time will be stamped on the time card and the workman given the next job. The duplicate copy of the time card will be taken out of the first pocket and destroyed, and the move card will be sent out and the job moved to the next operation. Then the time card for this operation will be found in the proper reserve machine pocket and will be shifted to the second pocket, and so on to the completion of the job. Meanwhile each operation as completed will have been checked off on the route sheet progress record, and the material tracer clerk will have checked the order at intervals and seen that it was properly pushed through the various processes.

Although this is probably the most elaborate system of those described, it is not as involved in actual practice as it is in description, as each operation is rapidly performed in routine fashion by a specialized clerk. Since the clerical work was functionalized so highly, and work flowed through in routine fashion, it generally took longer to get a rush order through the routine than with a simpler system. On the other hand, the total volume of work completed was greater,

and the actual total clerical time per order would probably be less than if a similar degree of control were attempted through the usual channels of the foreman's clerk, etc. The control of operations was very much better. This system was in use in a plant which normally had hundreds of small orders in process at any time, a situation involving a large amount of clerical work with any system of adequate control.

Dozens, perhaps hundreds of systems could be found to be added to the list of those described. A material control system should be as individual as a man's coat. Analysis should be made of the requirements of the situation along the general lines and principles indicated in previous chapters, and suitable devices and forms chosen or developed to meet each particular part of the problem. Each of the elements in the system, such as the schedule board or progress record, should be chosen with reference also to its relations to other parts of the factory system. For each of these single elements of the plan there is a choice among many devices and systems, as, for example, in scheduling, between the machine control board and the Taylor planning board. Only enough devices have been described fairly to illustrate the underlying principles of control.

CHAPTER XIV

ACCOUNTING AND COSTS

THE purpose of the factory accounting system is, first, to preserve a record of all transactions involving money values which take place in the conduct of the business, and second, to so classify and assemble these transactions as to present to the various executives involved a clear picture of the results of operation and of the financial position of the company. Only a very brief outline of the methods by which this is accomplished can be presented in this chapter, but a clear conception of the problems of factory management cannot be given without at least a brief discussion of this subject. For the sake of simplicity a majority of the illustrations are based on the assumption of an order cost system. This, although not the only common method of cost finding, is one of the most logical and easy to explain.

Theory of Accounts.—The theory of double entry bookkeeping is that in every transaction affecting values an exchange takes place, by which one party receives a value, while the other gives an equal value. Thus when a customer receives a shipment he is made responsible for or *debited* with the amount of the invoice, while the company, having parted with an equal value if we include profit, is relieved of responsibility or *credited* with an equal amount. The most elementary set of accounts would be a single proprietorship account in which the proprietor was debited with receipts of money or materials and credited with the giving out of these values. It is convenient to separate the proprietor's account into a number of separate accounts thus, one for real estate, one for materials, for accounts receivable, for

accounts payable, and so forth. These accounts will correspond with the reservoirs of capital shown pictorially in Figure 6, Chapter II. Thus the transformation of cash into raw material would be represented by a credit to cash and a debit to materials. By this system of equal charges and credits the total amount of capital in the business will remain unchanged on the books, save for the periodical reckoning of profit and loss.

Books of Account.—The record of these transactions is made in two steps. First a record of each transaction is made chronologically in a day book or *journal*. Thus one entry in effect might be, "Mar. 22—credit cash, $10.00, debit materials $10.00, for lumber purchased from John Doe." This entry may be shortened by providing columns for indicating the accounts to be debited and credited, and by indicating the account by a number or symbol. A typical "card of accounts" is shown in Figure 56.

The second step in recording the transaction is the posting of the journal entry as a debit or credit to the necessary *ledger account*. Thus for the transaction shown, Cash, account Number 210, would be credited or relieved of responsibility for the $10.00 paid, and Materials, account Number 231, would be charged or made responsible.

Reference is made in the card to *control accounts*. Since there may be many hundreds of small individual accounts in one general class of accounts such as accounts receivable, it is convenient to keep a separate account in which all transactions which are of one type are summarized. To keep a control account for accounts receivable, therefore, each time any particular customer's account was credited, the controlling account would theoretically be correspondingly credited, or debited as the case might be. Practically only totals of these detailed transactions are posted to the control account. By thus keeping a duplicate record of totals two purposes are served, first a check on errors in entry, since the two totals must agree, and second the convenience of having available

CARD OF ACCOUNTS

John Doe & Company

(Account numbers ending in 0 indicate classes of accounts which would be subdivided to suit the needs of the business.)

- 100 Capital Assets
    - 111 Land
  - 120 Buildings and Equipment
    - 121 Buildings
    - 122 Machinery and Equipment
    - 123 Office Furniture and Fixtures
  - 130 Reserves

- 200 Current Assets
  - 210 Cash
  - 220 Accounts and Notes Receivable
  - 230 Inventories
    - 231 Raw Material
    - 232 Work in Process
    - 233 Finished Stock
  - 240 Prepaid Expenses

- 300 Liabilities
  - 310 Accounts and Notes Payable
  - 320 Accrued Accounts

- 400 Proprietorship and Surplus
  - 410 Capital Stock
  - 420 Surplus
  - 430 Surplus and Contingency Reserves

- 501 Profit and Loss

- 600 Sales and Revenue
  - 610 Sales
    - 611 Deductions and Allowances
  - 620 Miscellaneous Revenue

- 700 Selling Expense
  - 710 Salaries and Commissions
  - 720 Miscellaneous Selling Expenses
  - 730 Advertising Expense

- 800 General Administrative Expense
  - 810 Salaries
  - 820 Supplies and Stationery
  - 830 Rent
  - 840 Taxes
  - 850 Insurance
  - 860 Interest Paid

900 Cost of Sales
 910 Merchandise Purchases
 920 Direct Labor
 930 Factory Expense Accounts
  931 Salaries and Indirect Labor
  932 Maintenance and Repairs
  933 Supplies
  934 Freight and Cartage
  935 Insurance
  936 Taxes
  937 Depreciation
 940 Distributed Expense Account
1,000 and up, Production Order Number Series

Fig. 56

CARD OF ACCOUNTS.

at all times the total of each of the important classes of accounts.

In modern bookkeeping this system of two-stage entry of the transaction by daybook and ledger is preserved in principle but usually shortened in practice by filing certain original records, such as the duplicate copy of the customer's invoice, in place of making the journal entry.

To ascertain the correctness of the ledger entries a *trial balance* may be taken by listing the debit or credit balance in each account, when the sum of the debits should equal the sum of the credits if all accounts are in balance. Certain errors which do not affect the balance may fail of discovery by this method.

Closing the Books.—The ledger accounts as described, include both real accounts, representing actual property values, and certain other accounts such as rent, taxes, labor, etc., which do not represent actual tangible assets, but only expenses incurred in the carrying on of business. These latter accounts are known as nominal accounts, and to ascertain the actual result of operations for a period, these nominal accounts must be balanced off and cleared from the books. This is done by closing them into an account known as *profit*

and loss. If this account of profit and loss is debited with all expenses of doing business and credited with the gross receipts from sales and other sources, the balance will evidently represent the profit, or loss if there be any. This balance, which we will assume to be profit, may now be credited to the proprietor's account, representing the net result of the various expenditures and receipts of the period.

Omitting some of the auxiliary or alternative entries which would be made in practice, the chain of entries by which the value equation is maintained in this series of transactions would be somewhat as follows:

$100..Debit cash.	Credit proprietorship for contributed capital	$100
50..Debit expense.	Credit cash	50
100..Debit accounts receivable.	Credit sales	100
50..Debit profit and loss.	Credit expense	50
100..Debit sales.	Credit profit and loss.......	100
50..Debit profit and loss.	Credit proprietor	50

Financial Statements.—The results of these entries may be presented in a *Statement of Profit and Loss* such as that shown in Figure 57 below. In this statement the gross sales

Statement of Profit and Loss

Gross sales	$1,000,000
Less discounts and allowances....................	30,000
Net sales	970,000
Less cost to manufacture........................	600,000
Gross profit	370,000
Less administration and selling expenses..........	150,000
Operating profit	220,000
Less interest paid	100,000
Net profit	$120,000

FIG. 57.

PROFIT AND LOSS STATEMENT.

are set up and the net profit is obtained by successive subtraction of the various classes of expense.

We may now present the financial condition of the company in a *Balance Sheet* which may be drawn off as the total of all the real accounts remaining after closing the nominal accounts into proprietorship. In the above skeletonized example the balance sheet would be:

Assets		*Liabilities and Capital*	
Customers' accounts	$100	Proprietorship	$150
Cash	50		

A balance sheet showing the form and items typically found for an industrial company is shown in Figure 58.

Cost Finding.—The system of accounts, described above, shows clearly the aggregate results of operation but it does not make a separation between the results for particular lines or products. Costs of such products may be ascertained either by a further subdivision of the general accounts, or by independently reckoning up the amount of labor, material, etc., expended on the order, using the general accounts only to ascertain the percentage of overhead to be added to cover those items of a general character which cannot be directly allocated to particular orders.

Purposes of Cost Finding.—Some reference has already been made to the method and purpose of ascertaining costs. It is quite possible to conceive of a factory in which the margin of profit would be sufficiently high on each article so that there would be no question of the advisability of manufacturing it, and in which direct supervision and observation of the various processes would be sufficiently close so that the management could be reasonably assured that there was no substantial loss resulting from inefficiencies. In such a case a cost system might contribute little or nothing to profit. Many businesses in fact run smoothly and profitably with no other records of cost than are obtainable from the general financial books of the company, or at best from an occasional estimate and check-up of direct material and labor costs.

Doe Manufacturing Company.
Balance Sheet as of June 30, 19....

ASSETS.		
Current assets:		
Cash	$110,348.22	
Customers' accounts receivable, less reserve	125,503.41	
Inventories	948,380.65	
		$1,184,232.28
Investments:		
Stock in subsidiary companies....		$200,600.00
Prepaid expenses:		
Unexpired insurance premiums...	$9,481.54	
Prepaid interest and taxes.......	6,841.00	
		$16,322.54
Fixed assets:		
Real estate, buildings and improvements	$2,643,980.24	
Less reserve for depreciation to June 30, 1923	360,401.00	
		$2,283,579.24
TOTAL ASSETS		$3,684,734.06
LIABILITIES.		
Current liabilities:		
Notes payable	$60,000.00	
Accounts payable	67,241.75	
		$127,241.75
Accrued liabilities:		
Federal taxes	$18,041.15	
Payrolls	4,002.85	
Customers' credit balances.......	3,481.20	
Sundry accrued items...........	1,420.43	
		$26,945.63
First mortgage bonds.............		$600,000.00
Special reserve for contingencies...		$100,000.00
Net worth:		
Applicable to preferred stock.....	$1,000,000.00	
Applicable to common stock......	1,200,000.00	
Surplus	630,546.68	
		$2,830,546.68
TOTAL LIABILITIES		$3,684,734.06

FIG. 58.

BALANCE SHEET.

With closer margins or more involved manufacturing problems, however, there is a serious danger that without adequate knowledge of costs, unsuspected leaks will creep in, which will seriously diminish profits. For one thing, a good cost system shows separately and accurately the cost of each of the several lines of product made. Often some line will be found to be made actually at a loss, the loss being concealed by the profit on another line, since the general accounts do not usually separate the various lines of manufacture. The cost system shows up and makes it possible to eliminate or correct such parasitic lines. It tends also toward a more accurate realization of and provision for such unseen expenses as depreciation, spoiled materials and waste. It is also of value in comparing efficiencies as between one department or one period and another, thus making possible the detection of leaks and inefficiencies. It also gives the information necessary for correct setting of selling prices where these are not already fixed by competition.

Methods of Collecting Costs.—Two systems of cost finding were referred to, one in which the costs may be obtained by subdivision of the general accounts, a second group in which no attempt is made to tie costs in with the general accounts. To provide for finding the costs by the first method it will be necessary to expand the rudimentary set of accounts used as an example on page 210 to include new accounts. The real accounts, proprietorship, cash, materials, machinery, customers' accounts, etc., will remain unchanged, but an account will be added for work in process, and one for finished materials. When an order is issued for the manufacture of a customer's order we will now as before credit materials and the proper expense accounts for materials, direct labor, and general expense expended on the order. We will debit work in process, the debit being made on a cost sheet, one of many whose total amount comprises the work in process account. A controlling account will also be kept separately to show this total amount. One form of the cost sheet is illustrated

For .... Job .... Record of Job No. ....
(Name of Customer) (Description)

.... Date received ....
.... Date promised ....
.... Quantity ordered ....
.... Date billed ....
.... Quantity delivered ....

Material and Purchased Items					*Labor Items*					Summary of cost		
Date	*Quantity*	*Kind*	*Price each*	*Amount*	*Date*	*Employe*	*Hours*	*Rate*	*Amount*	Materials and purchased items		
										Labor cost		
										Labor hours		
										Burden at $ .... per hr.		
										Factory cost		
										Selling expense		
										Cost to sell		
										Billed at		
Total material cost.					Total Labor							

FIG. 59.
COST SHEET, LABOR HOUR METHOD.

in Figure 59. Cash expenditure incurred for direct labor or material will be posted to this cost sheet from the respective time card or requisition, and the cost sheet will also be charged with a proper proportion of the expense, the corresponding expense accounts being credited through an intermediate "Factory Expense" account.

With the completion of the job the Work in Process account will be credited (the cost sheet being closed and filed and the controlling account credited with its total). The Finished Stock account will be correspondingly debited, and with the shipment of the goods Finished Stock will be credited and cost of Sales account will be debited with the cost of the goods sold. Sales will be credited with gross sales, and debited with cost of Sales, leaving a credit balance, if the business is profitable, which may periodically be closed into profit and loss.

Non-Balancing Systems.—The system described gives the most accurate and dependable results, but involves some additional expense for bookkeeping. In many industries in which costs change but little from one period to another, simpler and more approximate systems may suffice, and it is probably true that a majority of factories use cost systems in which no attempt is made to tie the costs in with the general accounts by the method described.

One such system is to use a cost sheet similar to Figure 59, collecting costs just as described except that the individual cost sheets are not balanced with the work in process account. It may be sufficient for the purposes of the management to collect this cost information only at occasional intervals. Then the material requisitions and time cards would be made out just as before, charging the proper job, and serving the usual purposes of timekeeping and material record, but only at intervals would they be assorted and posted to the job cost sheets.

Figure 60 shows the steps taken in collecting costs in a representative job cost system.

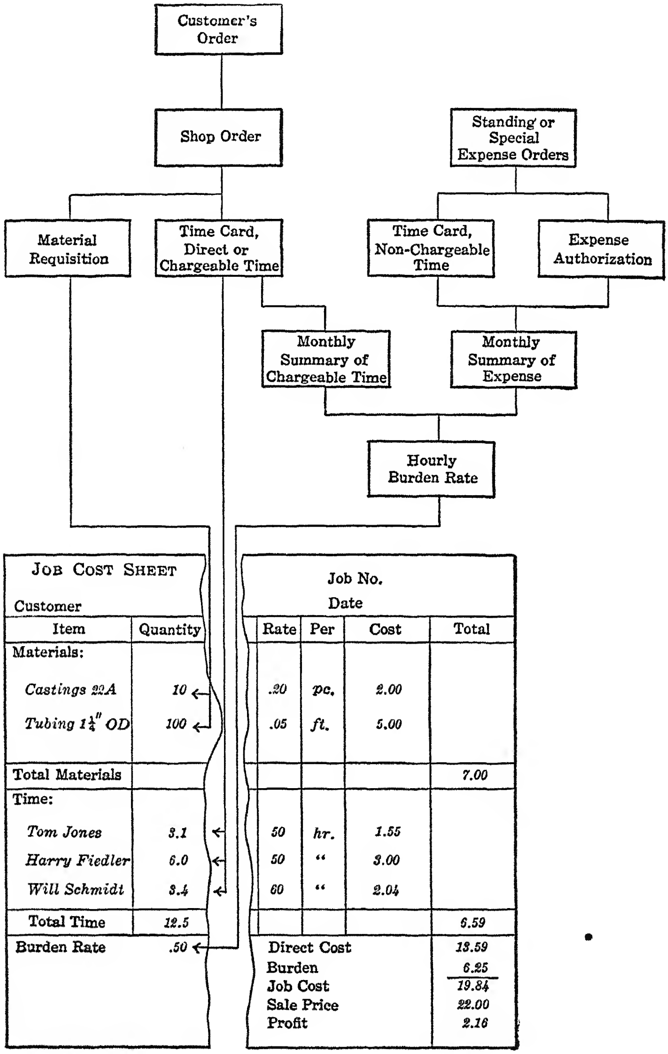

FIG. 60.

PROCEDURE IN FINDING JOB COSTS.

Test Run System.—A simpler but more approximate plan is found in small factories or simple repetitive types, in which no record is kept of the expenditures on individual orders. Here careful measurements are made of the amount of materials used, with due allowance for scrap, and labor costs are ascertained by making a test run, during which careful records of time, output and cost are kept. Where most of the work is paid by the piece the labor cost is still more simply obtained. Labor costs per piece are of course known, and with any change in material prices the material cost items on the cost card will be revised. At intervals the test run will be repeated as a check. The only remaining variable, the overhead expense, will be periodically ascertained from the general accounts. A further approximate check may be made by comparing the cost of production for the period at this ascertained price, with the total expenditures of the period for labor and material as shown by the books of account, the actual amount of production being obtained by comparison of the opening and closing inventories for the period.

A still simpler case is of course presented where only *one product* is made, in which case the cost is the total of all expenditures for a period, divided by the output for the period. No question of classification or division of expenses between orders enters here.

Process System.—Where the product is manufactured repetitively another plan of collecting cost is frequently used. Here the cost of each *process* is ascertained, the labor cost being collected continuously and totaled monthly or periodically for each process. Thus the cost of grinding pistons would be ascertained by dividing the labor cost at the grinding machines for the month by the output of the machines. The product cost will evidently be the sum of the various material costs and of the total of the unit process costs. This method would lead to some inaccuracies where the different orders required variable amounts of time, but is quite exten-

sively used where the whole product, regardless of minor variations, passes uniformly through a fixed series of operations. More accurate costs may be obtained by keeping separate the work done on various lots at a process. Thus if one hundred hours of work produce one hundred units of part A, at a process and one hundred hours produce seventy-five units of B, the total work and output during the month on each lot may be kept separate and an accurate process cost obtained for each.

By-Products Costs.—A difficult question is raised where the residue of one process is utilized for the production of some by-product, as where short blocks of wood sawed off in one process are made up into toys, or chemical wastes are reclaimed, yielding salable by-products. Where there is an established market price for the waste or for a corresponding grade of material, it would be proper to credit the cost of the original product and debit the cost of the by-product with this market value. Where there is no such standard of value the value of the waste would be set by an estimate, in making which consideration would be given to any extra expense entailed in securing the waste in usable form, to the proportion of the by-product contained potentially in the raw material, and to questions of policy, such as the relative keenness of competition in the various lines. Such considerations of expediency have no place in the pure theory of cost finding but do to an extent affect practical decisions.

Expense or Burden.—In addition to expenses directly chargeable to the product or customer's order, there are many expenditures which bear only an indirect relation to the individual order, many of which, in fact, must be incurred whether much or little output is produced. One class of such indirect or burden expenditures is really composed of expenditures which are direct, but too small to permit of separate record. Thus small supplies, sandpaper, paint, etc., are really used up on separate jobs, a fraction of a cent or so to each job. The same is true of trucking and some other types of

labor in which the man works so short a time at each job that is is not profitable to separate the items. A second class varies with output, but not directly or proportionally. Thus power bills are higher with larger output but not proportionally, for shafts and idle pulleys are run even when the machine is not working. Similarly, with shop supervision, clerical expense, depreciation of machinery and many other items. There is a third class of fixed charges, such as rent, interest on bonds, capital taxes, depreciation of buildings, which goes on practically independently of output, or even if operation is temporarily suspended altogether.

The Distribution of Expense.—The problem of expense distribution is to find some method, necessarily somewhat arbitrary and approximate, by which these general or unattached expenses of production may be absorbed into the costs of the production of the specific order or product, in some fashion which is as closely proportional as possible to the actual incidence of the expense and is at the same time not so elaborate as to entail undue clerical expenses. Thus we cannot tell precisely what the cost of power is for any individual order, but by finding out the average use of power by a particular machine and charging the product at an hourly rate for its use of the machine, we may approximate a correct distribution of the particular expense item of power.

Production Center Plan.—The most accurate method of expense distribution is undoubtedly the production center plan described by A. H. Church. His plan is to treat each machine or other producing unit, sometimes a whole group of similar machines, as a semi-independent little shop. The normal use of a punch press may be two hundred hours per month. Against this output must be charged the month's expenses, depreciation of the machine, power consumed (as measured by a test of the horse power of the machine), light and rental (based on the number of square feet of space occupied) and a percentage, estimated as closely as possible

in accordance with the actual facts, of the general supervision and other expenses of the factory. This hourly operating expense or machine rate would be ten or fifteen dollars an hour for a big printing press, costing perhaps a hundred thousand dollars, occupying many square feet of floor space and requiring costly supervision. It might be but a few cents for a simple work bench. Whatever it is, the machine time will be recorded, and the machine earnings charged to the job exactly as the man's earnings are charged, the machine number being noted on the man's time card and the rate looked up, extended on the card, charged to the job cost sheet and credited to factory expense.

One problem which arises with this system is the distribution of idle or unearned machine time. The burden rate is based on the normal hours of use (not total hours working time, since it is often necessary to buy expensive machines which are habitually used only a few hours per month). If the machine is not employed at this normal rate of use it will not earn its burden and there will be at the end of the period an amount of burden not distributed to the work. It would produce very distorted costs to try to charge some single unfortunate job which happened to use the machine in a period of idleness with the total burden for the month. Church's remedy for this difficulty is to treat this expense of idleness as a general expense, and to add it as a supplementary rate to the burden to be distributed to the coming month.

If jobs are priced on the basis of cost this would mean that the less the volume of orders the higher the unit cost would be, whereas the practical situation in this case usually calls for a lowering of prices to secure more business. To remedy this and prevent distortion of costs H. L. Gantt proposed that instead of treating the loss due to idleness as an expense, it be carried direct to profit and loss, as a hazard of business or an expense of bad management. This is theoretically more in accord with the facts. In the long run the loss would have to be recouped by a higher average rate of

profit, and would come to the same thing as with the other system, except that it gives a somewhat clearer picture of what is happening. A good alternative method is to set aside part of the surplus as a special reserve against idleness.

Excellent though the production center system is, however, it is a somewhat costly one to operate. Changes in equipment keep taking place, and each change requires resetting of the machine rate. There is also the additional labor of extending and posting the machine time. There are many cases where more approximate systems will give really as effective a distribution of expense.

Labor Hour.—Probably the most commonly used of all systems is distribution on the basis of the *labor hour.* Under this system the total expense for the period is divided by the total number of hours worked, and the resulting expense per hour is applied to the cost of the job for each hour worked. Thus, if during a month, 10,000 hours are worked, and the indirect expense is $6,000, a rate of 60 cents per hour is applied as burden. If a job carries ten hours of direct labor time an item of $6.00 expense would be added on the job cost sheet. Since this computation is made on the basis of the previous month each time, there will usually be a small unabsorbed plus or minus balance to be carried forward and absorbed in the next month's burden. As regards supervision, office expense, and many of the other expenses, the labor hour plan provides a comparatively accurate method of distribution. It is also correct when there are no great differences in equipment, all the machines being similar or so inexpensive that their burden would not be significant.

This labor hour method may be refined somewhat and made to approach the production center method by using different rates in different departments. For example, if one department is equipped with heavy presses, another with benches only, a higher rate could be used in the machine department. But where labor is the large item in cost, the simple labor hour method is usually adequate.

Other Plans of Distribution.—Other methods are also used. In the *labor cost* system the burden is distributed as so much per dollar of labor, instead of per hour. It is not as accurate as the labor hour method, but simplifies the bookkeeping slightly. In the so-called *"old machine rate"* which was the predecessor of the production center plan, the production time of the machines, instead of the men, is used as a basis for distributing burden. In the *prime cost* method, the prime cost of the product (material and direct labor) is the basis of expense, and so many cents of burden are added to every dollar of direct labor and material cost expended on the order. It is a somewhat rough and ready method, not as accurate as the labor hour method except under very uniform conditions, since material cost bears no definite relation to other manufacturing expenses.

Depreciation.—Depreciation is the normal wear and tear of machinery, and should usually include an allowance made for its possible obsolescence or becoming out of date. All equipment, except items of permanent value, such as land, is being slowly used up and its expense must in some way be absorbed by the product it is turning out. Since the cost of replacement does not fall uniformly over the period but comes in a lump when a new machine must be bought or irregularly when repairs which extend the life of the machine must be made, it is customary to provide a depreciation reserve. This may conceivably be an actual accumulation of cash, but customarily it is an amount annually charged to expense and credited to the reserve. The unabsorbed cost of the machine plus its reserve will thus remain constant and the machine will be fully written off during its estimated life.

Various methods are in use for estimating the annual decrease in value of the machine. In the case of machines in which wear has a definite relation to use a certain amount of the value of the machine may be written off per hour or mile or other unit of use. Another method is the "declining balance" method, in which a certain percentage of the remain-

ing value of the machine is written off annually. Another method is the annual physical appraisal of the value of the machine, the difference between the present and previous appraisal being written off. Another is the "sinking fund" method, using which an amount is set aside each year, such that, with its interest calculated, it will yield as a matured annuity at the end of the expected life of the machine the difference between the first cost and the scrap value of the machine.

The simplest and most generally used method, however, is the "straight line" method, by which, if the value of a machine is \$1200, its scrap value is \$200, and its estimated useful life ten years, \$100, or one-tenth of its net depreciable value, will be written off each year of its life.

Small tools are usually treated as an expense, and absorbed during the current year, since their value after a year's use is uncertain. The cost of special appliances, fixtures, etc., required for the customer's job and not certain of subsequent use is charged to the specific job, a deduction being made for remainder value. If the manufacturer is tender-hearted he will give the customer the benefit of the charge by making a lower price on subsequent jobs which may use the same equipment.

Accounting Entries for Distribution of Expense.—The entries by which the various expense accounts would be distributed to the product would be as follows: Credit the particular expense account, such as taxes, salaries, etc., and debit an account set up for "Factory Expense" (940 in the card shown). Credit this account and debit the job cost sheet (Work-in Process) with the amount of expense chargeable as determined by the production center, labor hour, or other method of expense distribution used.

Selling and general administrative expense might be included in the expense rate applied to the job, but are more usually applied to the factory cost as a separate percentage, based, for example, on cost of the product. They may also

be separately applied in the operating statement as illustrated in Figure 57.

Predetermined Costs.—The use of the cost system as part of the plan of budget control of the factory is referred to in Chapter II. It is possible either to set up the standard costs from experience, to serve as a comparison with real costs, or actually to charge out the product in the factory accounts on the basis of the predetermined costs, carrying any plus or minus balance resulting from actual operation into an adjustment account.

Standard Trade Association Systems.—One of the important practical advantages of cost accounting is that it shows a man what his actual expenses are and prevents his selling below cost. Selling below cost is as ruinous to the man's competitor as to the man himself, since the competitor also must meet the price or lose business. A realization of this common interest in a true knowledge of costs by all members of trade has brought about a very widespread adoption by trade associations of uniform cost and accounting systems, usually devised by an expert cost accountant and approved and adopted by the association. Typical of such systems is that of the United Typothetæ, the printers' association. It furnishes to members of the association, or to any interested printer (since its widespread adoption is to the interest of all), a complete set of forms for cost finding, a recommended classification of expenses, a plan of distribution on a "sold hour" (direct labor hour) basis, and recommended percentages based on experience for depreciation allowances for the various classes of equipment; interest rates used, and other expenses. (It may be noted that the inclusion of interest in costs is a matter on which accountants differ, the more widely accepted theory being that interest should be treated as a profit, not a cost, except where actually paid for borrowed money.)

Similar standard systems have been worked out for retail clothing and shoe store associations, shoe manufacturers, furniture manufacturers, and a wide variety of other indus-

tries. While not always adopted in toto they exert a strong influence toward uniformity in accounting method and consequently in the basis of price making.

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CHAPTER XV

SUPERVISION AND INSPECTION

CONTROL of the factory schedule, important because it is so basically connected with the general factory organization and control, has been discussed at some length in previous chapters, and financial and cost control by records have been outlined. Two other problems of control required consideration, control of quality by inspection, and supervision of the workmen by the foreman and their line superiors.

Inspection.—The engineering department or other designing agency furnishes the factory with a set of specifications, which if followed out will presumably result in a marketable and serviceable product. Presumably also, these specifications indicate minimum requirements, the lowest grade of material, the widest tolerances, which can be permitted and still obtain the desired quality, which may be very high or of lower grade. It is the duty of the inspection department to enforce these specifications. As a by-product of this enforcement it will more or less automatically accomplish the following purposes:

(1) Prevent the expenditure of additional time and material on spoiled work.

(2) Indicate defects in the process or design, such as faulty tools or worn dies, which result in rough or oversize work, imperfect design of patterns which would result in warped or defective castings, and many other faults whose prompt correction is important. For this purpose an inspection report is frequently required with defective work, which indicates what caused the trouble, whether carelessness of operator, poor material, defective tools, or other causes.

(3) Fix responsibility for poor work, particularly important with piece work systems, although important at all times.

The work of inspection is of various types. Sometimes it is very simple routine work. Thus to test the degree of magnetization of a telephone receiver magnet, a girl inspector passed it in a specified way in front of a combination inductance coil and electrometer, and, if the recording needle registered the required intensity on the scale, dropped the part into a tray of accepted parts, otherwise into a tray of work to be re-magnetized, or in case this proved impossible, rejected. Gauging is usually of this simple type, the operator having a high-low limit gauge and rejecting everything not falling between the two limits. For this work faithfulness to exact routine instructions, a liking for sedentary routine work, deftness, and ability for reasonably sustained attention are the principal requisites. Women frequently succeed better than men at it.

The rejects from this first inspection are often re-inspected. Depending on the nature of the work, this usually calls for quite a different and a less common mental equipment. Judgment, and ingenuity in finding ways to match oversize parts for example, or to correct errors so that the part can be used, are of importance here. This work of reclaiming such salvaged parts should be done in a room where the parts will not be accessible to some foreman who happens to be short a part and will be tempted to try to pick up a reject to serve in the emergency.

Inspection in non-routine processes also call for a higher degree of judgment and trade knowledge than does routine inspection. Here the inspector cannot work according to a single formula, but must be able to read blueprints and must understand the use to which the part will be put.

Organization of Inspection.—Under the pressure of production and cost, the urgency to ship some particular order perhaps already past due, there is a powerful temptation in critical cases to relax the standard just a little. The chief in-

spector should stand clear and independent of the production organization. This means that he should stand not lower in the organization than as a direct subordinate to the general manager, works manager, or an executive similarly removed from direct production problems and in contact with other executive phases to preserve a proper balance. Sometimes the chief inspector reports to the superintendent, but in this case frequently the engineering department is given a separate "engineering inspection" department which settles difficult cases and sees that standards are not relaxed.

Reporting to the chief inspector in any large organization will be foremen inspectors responsible for the larger divisions of the works. Under these men in turn will be, typically, one or two porters to assist in handling heavy boxes of parts, a sufficient number of counters, who count but do not inspect, a sufficient number of routine inspectors, and perhaps one or more travelling inspectors, who may be sent out to inspect specific jobs in the shop, and also go from machine to machine, checking up the quality of work of individual operators, etc. It is important that the first piece, produced at the starting of any operation, shall be inspected for correctness of dimension, method and finish, either by a travelling inspector or by the man's foreman. This makes it certain that the man understands instructions and that his equipment is in order, preventing many possible spoilages.

Various plans are used for the transportation of the parts to inspection. One common plan is to have an inspection crib in each department, the work being moved to the crib when the operation is finished, inspected, and moved to the next operation. Control of movement of material, the recording of time and giving out of new jobs may evidently in many cases be centered at the point of inspection or adjacent to it. Where the process is continuous the various inspections necessary will usually be located at the proper point in the process, like any productive process. Where the work is large and heavy, central inspection may have to be abandoned,

the inspector being sent to the job as it is completed. Evidently the inspection organization will usually be composed of scattered units, presenting problems of supervision which are best solved by carefully selecting responsible individuals who will work without the need of constant supervision, and then retaining these people by an intelligent labor policy.

Considerable economy is possible in inspection work by a judicious use of sampling methods and selection of strategic points for inspection. Parts from an automatic machine, for example, will only very slowly depart from the standard dimension as the tools wear dull, and it may be sufficient to check one part out of every thousand, to make sure that the lot as a whole is up to standard. Where the opportunity for variation increases, the ratio of inspected parts will be increased. The percentage of inspection varies also with the importance of perfection. If the part is to be assembled in the plant it may be cheaper to let a small proportion of imperfect parts get past, if they are easily detected by the assembler, than to go to the cost of 100% inspection. On the other hand, the irritation and ill-will caused in the customer when he pays his good money for a defective article, the disturbance of relations with the dealer, make it important that for the final inspection, in most classes of work, every part shall pass scrutiny.

Various considerations influence the selection of the process for inspection. Sometimes defects at one process will be concealed by the next process. Sometimes, as in hardening or heat treating, parts will be subject to special strains and will develop flaws. Sometimes a part may most conveniently be gauged at a certain stage of completion.

One point of importance in inspection is the maintenance of accurate master standards and the frequent checking with these standards, of the gauges and other inspection equipment. One firm's equipment for this work is as follows: First, a special master standard, a parallel-plane block of steel made by a Swedish specialist, kept in a vault at an even tempera-

ture and used only to calibrate master gauges. Second, a set of master gauges, calibrated from time to time with the master-block, and in turn used at regular intervals to calibrate the working gauges. Third, the working gauges. Gauges wear or are bent or distorted, thermometers and other instruments become untrue, and a constant watch must be kept. The United States Bureau of Standards maintains for the use of manufacturers and other interested parties a commercial testing bureau, in which such tests and calibrations are done for moderate fixed costs. The need of accuracy of course varies with the product. One ten-thousandths of an inch may be coarse for certain work, an inch sufficiently accurate for other types.

The inspector's crib is in danger of becoming a point of stoppage and a source of much irritation if it is not scheduled much as any other work would be. Adequate crews must be provided, and it is sometimes necessary to arrange the shifts so that inspection can be done after or before regular shop hours, so that production may start off promptly. Inspectors usually work on a day rate, although piece rate, with check sample inspection, is occasionally used.

Foremanship.—The design function, the supply of materials, machinery, men and money, the control of production, the cost records, are all of them auxiliary functions in the factory, which, as in lathe or other machine tool, supply the power and control of movement by which the cutting point of the tool, the function of actual operation, is brought to bear on the work. These functions are auxiliary in another sense; in spite of their intimate and routine connection with production, they may be regarded, and by the workman are regarded to a certain extent, as clerical in nature. These departments write the orders to which the "boss" signs his name.

These functional departments are in fact a newer organization form which has advantages in point of skill of performance over the older line organization under which men have

worked since the beginning of time, but which requires more complicated and less intuitive adjustments on the part of the men who work under it. In dealing with workmen, who as a whole are moved more by habitual and emotional than by intellectual considerations, it has been found wise to retain the old undivided and personal authority of the line boss. Taylor proposed and operated a system of functional foremanship, in which eight bosses and planning clerks directed the activities of the workman, but it is significant that the form in which Taylor's idea of functionalizing the work of supervision found final general adoption was a plan which, while it retained the basic idea of functionalization, went back to the older foreman as the connecting link between the man and the functional specialist.

The Modern Functional Foremanship.—The first point of direct organization contact with the workman is, under this modern plan, a foreman, who exercises as before a general control over the workman. To the workmen he represents the management, and aside from a certain necessary amount of "paper-work"—time reports, for example—the workman looks to him for orders, for promotion, and for leadership. But a foreman who can rise fully to this responsibility is so scarce that he is apt to be promoted out of the job as soon as he is found, so we bring the best abilities of our functional executives and departments to bear upon the workman through the foreman, who thus becomes a sort of a clearing house and coordinating point for the instructions of these departments.

Figure 62 illustrates the evolution of functional foremanship from the old type to the modern type.

Policies as to wage level, promotion, discipline, care of unfortunate employees, etc., are decided upon by the personnel director, whatever his actual title may be, and are transmitted to the foreman by means of regular instructions or orders, by personal and group conference, by advice and by review or appeal in case a mistake has been made by the foreman.

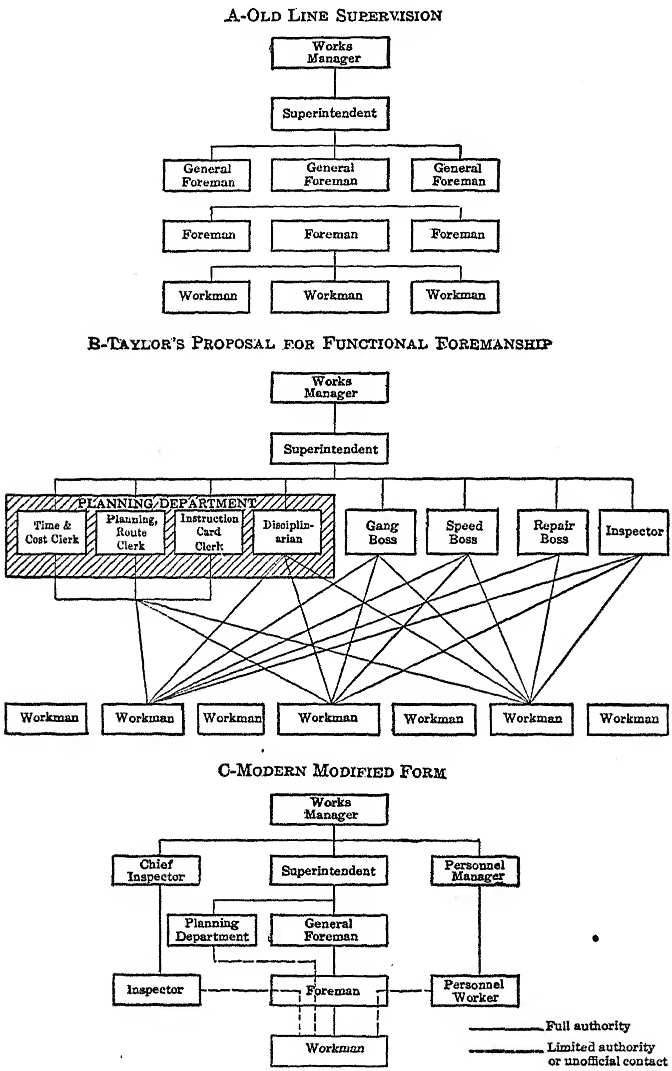

Fig. 62.

EVOLUTION OF FUNCTIONAL FOREMANSHIP.

Similarly the best method of tool operation, the proper cutting speeds, the use of improved technical processes, are worked out by the proper staff departments and either imparted to the workmen direct, with the cooperation and authorization of the foreman, or transmitted by instructing the foreman himself in the new methods. Care is taken in all these relations, while making it clear to the man that the foreman does not have the final word and that appeal may be taken for good cause, to make it clear also that the foreman does have the first word, that his authority is normally the only direct authority over the man, and that he will be supported in his rulings by the management except for very good cause.

The Superintendent.—This line hierarchy which constitutes the authority backbone of the factory starts either with the general manager, the factory manager, or the superintendent, depending on size and local conditions of the organization. The *superintendent* is in direct charge of a major producing unit—either the whole shop or an independent branch of the factory. His primary duty is that of carrying out the orders of the general management, orders which specify the materials to be manufactured, and which lay down certain general policies and limits as to the amount of inventory amounts to be spent for special purposes such as expansion of a department, wage levels and other policies, changes of design, major changes in personnel, major layoffs or overtime work, and similar matters. Within these policy limits he is given authority over the routine departments of operation, such as the production, stores, receiving and shipping, and sometimes employment departments, and over the foremen, and is held responsible for results.

The General Foreman.—The major divisions of a good sized factory are in charge of intermediate officials frequently bearing the title of *general foremen*. These men are virtually more limited superintendents, controlling direct operating departments only.

The Foreman.—The divisions of these departments, which comprise the operating units or groups, are in charge of foremen. The title of foreman is variously used, ranging from a man having subordinate bosses and virtually a general foreman, down to the local head of a group of half a dozen men—the foreman in the latter case often being called a gang boss. Generally speaking the foreman performs no direct operations, for his time is very fully occupied with the duties of direction and supervision. He is usually paid a weekly salary, with the vacation and sick leave privileges accompanying it, but this salary is for the less important foremen usually only slightly above that of the best men under him.

Leading Workman.—A still lower rank is found in the leading workman, who both works at his trade and supervises the activities of a small group, either in the absence of the regular foreman, or as a subordinate to the latter. Because of the rather uncomfortable position in which the leading workman finds himself at times because of his very limited authority, he is sometimes given the title of "straw boss" by the men.

Duties of the Foreman.—The foreman, as stated, acts as a clearing house for the orders received from the various departments. Production orders may clear through him, or if received by the workman from the planning department are usually shown to him by the man for detailed instructions before being started. He checks over finished jobs and approves starting a new job if the last one is properly done. He is expected to keep an eye on the various operations in process, to catch and correct mistakes or slovenly workmanship. He shows the men how to do work unfamiliar to them and acts as a general instructor in technical method. He confers with the planning department as to order of work for his department, calling attention to overlooked jobs and suggesting job sequences that will enable him to utilize his machines to best advantage, avoiding the tearing down of machine set-ups, for example. He sees to it that tools, drawings, and materials

are on hand before any job is started, reports defective machinery, and in general supplies any gaps in the control of the general management.

He is also the principal disciplinary force of the factory. The incoming applicant for work is usually sent for final approval to his prospective foreman before starting work, and his subsequent testing is to a considerable extent in the hands of this foreman. The latter recommends promotions, transfers, changes in rates, his recommendations being usually reviewed by the personnel department and his superior official. He supervises general discipline, imposes minor punishments directly, and recommends more serious penalties, such as lay-offs or deductions in pay or discharge, to the personnel department. If he is a tyrannical or avaricious man such abuses are apt to be found in his department as the paying for jobs by new men, or the pitiful buying of favor by fawning, or by bribes, such as the annual presentation of a gold watch, etc., "as a token of esteem and loyalty." If he is of better type his men will come to him in trouble as they would to a father, and such a foreman, supported by a management of corresponding type, acquires the enviable reputation of taking care of his men. Such a foreman looks out for the promotion and recognition of his subordinates, visits and if possible helps them when they are sick, takes sympathetic notice of the weddings, births, national holidays, and general good and bad fortunes of his clan. It is, after all, these understanding and personal relationships between management and men, more than conventional and elaborate welfare work which explain the morale or esprit de corps of a good organization. "Man does not live by bread alone."

Qualities for Foremanship.—The importance of the foreman in production has been very properly emphasized in the literature of factory management. The first step in getting good foremen is proper selection. Usually the foreman is selected from a group of employees who have already been under observation for some time. Some plan for rating em-

ployees such as that to be described in Chapter XVI may be used to advantage in selection.

Good judgment and ability to plan and organize his own work and that of others within a limited range are plainly essential. Good physical health, a sense of humor, and an even temper are important. Understanding of men and experience in dealing with them are present in very variable quantities in various men, as are tact, a sense of fairness, and the ability to recede with dignity from a false position. Personal character is of great importance, since the men take their cue from the leader, and either lose respect for, or tend to imitate, a loose or vulgar foreman, a drinker, an excessively profane man, one given to petty dishonesty and sharp practice, or one of warped social beliefs.

Figure 63 is a reproduction of a rating scale for foremen, following the general lines of Doctor W. D. Scott's method, which is further described in Chapter XVI.

Training.—While there is a great variation in the extent to which the qualities desirable in a foreman are found in various individuals, many of these qualities can be cultivated to advantage, and many companies have organized foremen's clubs or classes with this as one purpose. Thus the International Harvester Company has made a definite educational plan, supplemental to a plan of social organization of the foremen and assistant foremen already existing. This plan is designed to teach better manufacturing technique and understanding of the problems of management, to awaken interest on the part of the foreman in his work, and by stimulus of interest and discussion to lead to the development of new and better methods.

A training course of slightly different character has been given to the foremen employed by Swift & Company. Here a plan was used which placed the emphasis on sound economics and on the methods of handling men. Practical problems were given and the men met for discussion, which under the leadership of the conductor of the course and head

Foreman's name	Foreman rated by... Date
1. *Trade ability.* Consider kind and amount of trade (or dept.) experience: knowledge of and resourcefulness in using machines, tools, materials and trade methods.	Highest 15........ High 12........ Average 9........ Low 6........ Lowest 3........
2. *Ability to plan and supervise.* Consider ability to maintain standard quality work; to place men where they can do the best work, to plan ahead so as to have materials, men and tools ready to get out orders on schedule time with minimum production cost, and to keep a steady flow of work through the dept.	Highest 15........ High 12........ Average 9........ Low 6........ Lowest 3........
3. *Ability to handle men.* Consider initiative, decisiveness, resourcefulness, energy, self-control and ability to deal fairly with his help; to earn their respect, good will and confidence, to maintain just discipline and a stable working force.	Highest 15........ High 12........ Average 9........ Low 6........ Lowest 3........
4. *Ability to teach.* Consider ability to explain his work clearly and thoroughly to a beginner, to gain the beginner's confidence and interest him in his work; his success in developing all-round men, bettering men of lower grades and increasing generally the knowledge and value of the men under him.	Highest 15........ High 12........ Average 9........ Low 6........ Lowest 3........
5. *General value to the company.* Consider years of service, loyalty, ability to understand and carry out the company's policies, orderliness of his department, willingness to cooperate with other departments and the management, openness to new ideas.	Highest 40........ High 30........ Average 20........ Low 10........ Lowest 5........

FIG. 63.

RATING SCALE FOR FOREMEN.

of the Department of Industrial Relations, Mr. John Calder, ranged over the entire field of the men's interest, with special emphasis on personal and company problems.

Another approach to better foremanship has been the use of the apprentice course specially for the development of potential executives. Further mention will be made of this point in Chapter XVI.

As Tead and Metcalf point out in their book on "Personnel Management," the foreman is not only an official of peculiar importance in the organization, but is one whose position is of peculiar difficulty. His is a divided allegiance—to the men by the sentiment and traditions of his worker's past, to the management by virtue of his acceptance of his position, and of all his interest and opportunities for advancement. Faced with this issue he sometimes secretly and disloyally supports or even fosters the grievances of his men, sometimes he swings to the opposite extreme of undue harshness and contemptuousness toward his former equals in rank.

His duties furthermore are exacting, distracting often and exhausting, and he is peculiarly subject to the irritableness of fatigue. Anyone who has ever felt the strain of rushed production, when one's best may not be good enough and there seems no prospect of release from the strain of responsibility, can appreciate the difficulty of serene foremanship.

Practical aid can be given the foreman in his difficult work by good planning and control methods which keep things running smoothly and relieve him of unnecessary details, by proper original selection, by training, by providing enough foremen to take care of the work, and by the encouragement, recognition, support and leadership of superior officials.

Over-Foremanizing.—It is possible to over-foremanize. The foreman on the one hand should not be burdened with so large a number of men or so complicated a group of supervisory duties that he is unable to keep up with the administrative work of his position. Neither, on the other hand, should he have so few subordinates that he sets a bad example

of idleness to his men, or fusses with them "like a hen with one chick." In the killing and dressing of sheep in a large packing plant, one foreman supervises the whole operation, which takes place on two floors and employs over a hundred men. The operation is continuous and progressive, and trouble on the starting floor would quickly show up by stopping the later processes. Each employee knows his duty, which is unvarying, so that frequent decisions and instruction are unnecessary. In general, close inspection, good morale, steady employment and sound labor policies, strategic location of foremen and inspectors, and piece rate or other plans of payment based on production, tend to reduce the necessary number of supervisors and to develop without very much exhortation a feeling of responsibility for good discipline and good work among the men themselves.

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CHAPTER XVI

THE PERSONNEL DEPARTMENT

WITH the general tendency toward specialization, which has marked the recent developments in management, it is increasingly realized that the correct handling of men is in itself a highly specialized function, and the consequent tendency is to provide in the factory organization for a special personnel or labor department which is not directly connected with production.

This personnel department may in the small organization comprise only one man, who conducts the work of hiring men as called for by the foreman, frequently acts as a sort of "executive secretary" in the launching of social and other activities, and serves in a staff capacity, assisting the chief executive in the gathering of information and forming of policies as to personnel questions.

In the larger plants this function is expanded into what is frequently a considerable department, in charge of a man of major executive caliber who reports direct to the chief operating executive and is on the same authority level as the superintendent or works manager.

The work of the Personnel Department, Department of Industrial Relations, or Labor Department, as it is variously termed, includes part or all of the following functions:

(1) Examination and *hiring* of applicants for work.

(2) Keeping personnel *records* which give the history of each employee, as to attendance, efficiency, raises, promotions and other changes of status, character and performance ratings, etc.

(3) Trade *training* and general instruction and education work.
(4) Safety, *plant housekeeping*, medical and nursing work, dental work, etc., for employees, health supervision.
(5) Leadership of *social activities* among employees; picnics, clubs, etc.
(6) Supervision of plans for *financial* assistance of employees, such as pensions, mutual benefit sickness relief associations, insurance, sale of stock, savings plan, etc.
(7) Supervision of *wage levels*, and in collaboration with the production department, job analysis and rate setting.
(8) Supervision of plant *discipline* and *collective negotiations* with the men.

Figure 64 (see page 242) represents the organization for this work of the personnel department of a large company.

Employment.—With such a personnel department, hiring is centralized at one point, the employment office. Separate offices may be maintained for unskilled, skilled, and office help, and recruiting branches are sometimes located away from the factory, either temporarily or permanently, at favorable sources of supply. Requisitions for help are made out as required, by the various foremen, specifying occupation, number of men required, period of probable employment, wage to be paid, and requirements or preferences as to experience, age, type of man, etc. Sometimes the employment office has a file of job descriptions, to which reference is made in selecting the kind of man called for by the requisition.

Applicants are secured for these jobs in various ways. Newspaper "want ads," signs, premiums to employees for bringing in friends, are resorted to. Application may be made to employment agencies. Agencies operated by the state, by the trade association, by the trade union, or by individuals on a fee basis, are the principal types. Many men are secured on their own application at the factory for a job.

The Interviewer.—If the applicant is unskilled or a foreigner he will usually be selected almost wholly on the basis of personal interview. The interviewer while questioning the man will fill out a simple application blank which will be

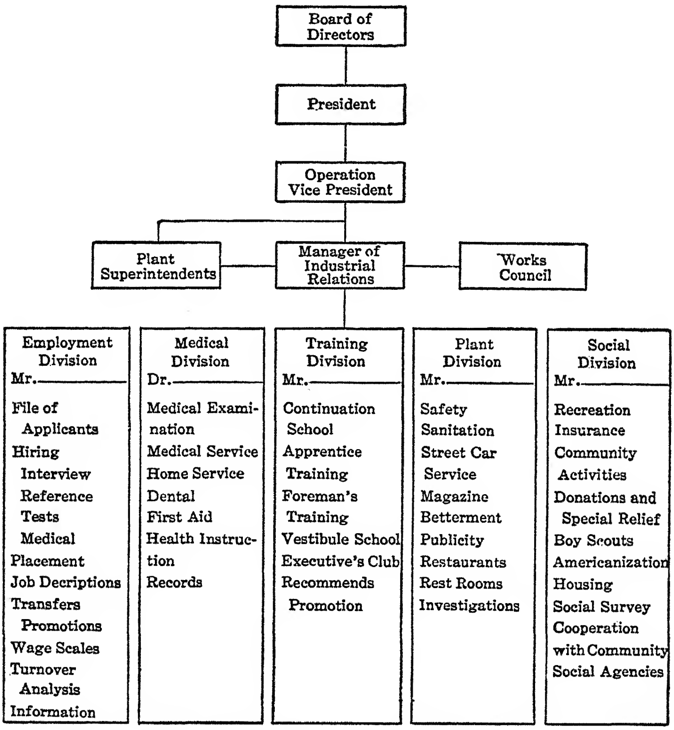

FIG. 64.

ORGANIZATION AND DUTIES OF THE PERSONNEL DEPARTMENT.

filed as a record of the employee, the latter will be given a pass and sent with a guide to the foreman, who himself examines the applicant and finally accepts or rejects him. He will then be assigned a clock number, tool checks, locker, etc., as required, and the routine of recording attendance,

receiving pay, etc., and of his duties explained to him. Some of the more progressive employers include as part of the introduction of the man to his duties an introduction to other men in the gang, and to the shop chairman if a union or works council exists in the shop. It is of much practical value in reducing turnover and wasted time to introduce the man pleasantly and systematically to his work and his associates, creating a favorable attitude at the start. If the applicant is for a skilled or permanent position, more attention is usually given to selection, and the applicant starts out by filling out his own application blank while waiting for an interview. The interviewer, in this as in all cases, will try to ascertain the man's experience and skill in the special type of work, his intellectual capacity and physical fitness, his previous history as to permanency of employment, insubordination, reliability, etc., and his general attitude. Skillful questioning will reveal much, but considerable work has been done in developing special tests of the various abilities required.

Trade Tests.—For quickly ascertaining the applicant's trade skill, the trade test has been devised. The applicant is asked questions involving familiarity with the names of tools or processes, or requiring judgment and information not possessed by the unskilled man. Or he may be required to perform certain test operations. Most foremen, without calling it by that name, have developed some sort of rough-and-ready trade testing. Figure 65 illustrates the type of questions used. The man may also be shown a picture of the machine he is to run and asked to name its parts and explain how he would work it.

Psychological Tests.—A second type of test is the psychological test, of which there are many kinds for various purposes. The general intelligence test gives some measure of the applicant's mental alertness and judgment by requiring him in a limited time to answer involved questions, to complete analogies, to follow puzzling instructions and perform similar operations selected to demonstrate a range of abilities.

THE CARPENTER'S TRADE—TYPICAL QUESTIONS.

APPRENTICE

1. *Question:* How many nails would you put in the bottom end of a 2" x 4" when used as a stud in a wall or a partition? What size nails would you use?
Answer: About four 10 d common.

5. *Question:* What is the length of a wood lath?
Answer: 4 feet.

9. *Question:* What does scribing mean?
Answer: Fitting to an irregular surface.

JOURNEYMAN

1. *Question:* In setting a floor joist which edge would you use for the top and why?
Answer: The crown, to overcome the tendency to sag from its own weight and that of the floor.

5. *Question:* What figures on the steel square would you use in marking a mitre?
Answer: Any two equal figures.

JOURNEYMAN EXPERT

1. *Question:* Name the various rafters used in framing a roof.
Answer: Hip, jack and common.

4. *Question:* When would you nail the bottom end of the cross-bridging between floor joists and why?
Answer: After the floor has been nailed down, to pull the joist into line.

FIG. 65.

TRADE TESTS USED BY THE U. S. ARMY.

The correlation of properly designed general intelligence tests with the individual's general intelligence as judged by other means (such as group judgment or the individual's history) has proven high, and they are a valuable corroboration although not a final measure of the individual's intelligence. They reveal little as to attitude and motivation of the worker, faithfulness, and similar emotional and will characteristics without which even an intelligent man is of little value.

Various tests of special abilities are also in use. Thus the

ability for sustained attention is tested by giving the applicant a certain time to cross out all the "n's" in a random column of the morning paper. Color perception may be tested with a color scale. Memory in various directions may be tested by giving the applicant a number of named photographs, later to be identified when shown unnamed, or giving him figures or messages to reproduce. Muscular coordination is tested by having the operator, working in time with a fixed rhythm, pick up and insert pegs in a row of holes in a "match board." Quickness of reaction time, useful in selecting speedy routine workers, inspectors etc., may be tested, and tests have been worked out for a variety of other physical and mental qualities.

The Rating Scale.—A method of selection sometimes used for the more important employees such as salesmen, and frequently and effectively used for judging old employees, is the rating scale. The various qualifications required for the position are listed and assigned weights indicating relative importance. Members of a group of superiors or associates who have had opportunity to observe the individual's performance then independently list him as "excellent," "average," "poor," or on a percentage basis, or by comparison with selected type individuals, on each of the specified qualities, the total rating being then computed. This is a very practical plan for keeping track of men after employed. The periodical rating brings to light good men, and has the incidental valuable result of training the superior himself in accurate and balanced judgment. See Figure 63, Chapter XV, for a foreman's rating scale.

The psychological test has given excellent results in a large number of instances. It has been the experience of some firms, however, that a skilled interviewer, perhaps incorporating in an informal way some of the test methods into his interviewing, can for many types of work make nearly as good an estimate as that furnished by the test. One useful result of the development of these tests should be the improve-

ment of interviewing methods, and the tests themselves effect economies where the cost of training the applicant is high.

One very generally used supplement to the personal interviewer is the medical examination, valuable in preventing men from entering work which would be injurious, in keeping contagious disease out of the shop, for furnishing evidence in case of later compensation claims for occupational disease, and as a means of getting the men started in coming to the doctor regularly for subsequent examination and preventive medicine.

Keeping Track of Men.—With the hiring of the applicant the process of selection is really only begun. The great majority of employees of any well-managed organization enter it in routine capacities and are selected for advancement after a considerable period of observation and trial. To make this process systematic and inclusive and to enable the organization to find needed men in its own ranks instead of going outside should be one of the important functions of the personnel department. A record of each individual, his earnings, attendance, discipline, and achievements, together with some plan of periodical appraisal such as the rating plan mentioned, should be kept. All recommendations for advancement should be approved by the personnel department (for record only, usually, in the case of higher executives) and the files should be gone over periodically and consideration given each man who deserves an increase or a promotion. It is better policy, especially in the large organizations, to give raises systematically, in accordance with impartial standards, and without the need of asking, than it is to allow the raises to go to the importunate ones, while good employees who are less vociferous become discouraged or secure better jobs elsewhere. Vacancies are constantly occurring because of promotion, retirement, leaving, and other causes, and new men are constantly coming in from the bottom. Because of this, even in the case of the man who is not promoted, increases of pay within a limited range can be given without disturbing

the average level of wages, and the employee can be given a sense of encouragement and progress and a reward for faithfulness. Promotions and raises are useful means of building up loyalty and a good esprit de corps, if they are rightly handled; nothing breaks down morale more quickly than niggardliness, partiality, or inattention in this matter.

SERVICE RECORD

Name ______________________ Address ______________________

Occupation ______________________ Phone ______________________

Nationality ____________ Date of Birth ____________ Dependents ____________

U. S. Citizen ____________ Sex M/F ☐ Color ____________ Education ____________

Date	Occupation	Number	Day Rate	P. W. Rate	Remarks

Rating	Date of Rating	Performance Qualities	Accuracy	Carefulness	Knowledge	Skill	Speed	Total	Cooperative Qualities	Team Work	Dependability	Industry	Conduct	Tact	Total	Intelligence Qualities	Analytical	Judgment	Perception	Resourcefulness	Teachability	Total	Physical Qualities	Activity	Endurance	Health	Physique	Strength	Total	Leadership Qualities	Initiative	Leadership	Self-Confidence	Self-Control	Humor	Total	Grand Total

FIG. 66.

EMPLOYEE'S SERVICE RECORD.

A typical record card for shop employees is shown in Figure 66.

Training.—Most of the men who apply for work at the factory (except for work classed as unskilled) have had some experience and know a trade or an operation. But a percentage of the men must be taught the trade from the beginning, technique of present employees must be improved,

and a chance given in some cases for a man to learn a new job.

Probably the most effective method of training for single operations, or for jobs requiring habit-skill rather than judgment, is the vestibule school, so called because it acts as a vestibule through which the employee passes before entering regular production. The vestibule school usually is separated from the productive departments and is equipped with a limited number of machines of the principal types. A trained instructor gives it his full time. The new operator is brought into this school and intensively supervised by the instructor in learning one or a group of operations. The training may take from one day to three months, and the operator usually receives day wages while in training. Best results have been secured where the operation to be learned is broken up into very small steps, and each step mastered and work habits formed before the next one is attempted.

An older plan, now less used for general training because of the time and cost involved, is the apprenticeship plan. Here the applicant, usually a youth between fourteen and twenty years old, enters the shop at a comparatively low wage, and under an agreement to work from one to four or more years, during which time he is rotated from one job to another and taught the trade by the foremen. Class instruction usually supplements this training and a supervisor is provided to direct the boys, question them about the work, and help them decide the line in which they wish later to engage. This is probably not as economical a method as the vestibule school for training routine workers, but is the best method for developing foremen and skilled workers of the type able to originate or independently execute high grade work.

Evening classes in drawing, business English, shop and accounting methods, engineering, typewriting, arithmetic, and similar subjects are also used to develop ability of employees. Often a foreman's club or social organization is made the nucleus for a study group, directed by members of the organ-

ization or using a correspondence or a specially prepared course as an outline of study.

Probably the most widely used of all teaching methods in industry is by example and imitation. The new clerk, for example, is assigned to an older man for a day or two, first watches his preceptor make the entries and has them explained to him, then makes them himself under direction, later asking questions as new points arise.

The engineer starts as a fireman, the molder as a helper, the face brick layer on the rougher interior work and the plasterer as a hod carrier. And many a promising executive has sat in the school of an older executive's office, as office boy, and learned by imitation, by casual suggestion, and by independent study the older man's methods and philosophy. Here again the process may be made more effective by organization, by a process of selecting promising material for promotion, by planned rotation of experiences which develop breadth of view and experience, by an emphasis for the older men and leaders, on the importance and the methods of training.

The Western Electric Company of Chicago is an interesting example of the possibilities to the large corporation of this systematic development of its personnel—interesting not only because of the variety of training opportunities offered, but because of the deep-reaching effect which twenty or more years of effort in this line has had in developing a highly organized group, of predominantly engineering attitude and approach. Among the facilities offered by this company are the following: An apprentice course for tool makers and other trades, open to high school graduates and, under certain conditions, to others. A special one-year apprentice course for college graduates, leading to work in the engineering, shop operation, or commercial branches of the organization. A system of classes in drafting, English, shop methods, tracing, typewriting, psychology, arithmetic, and other subjects, managed by the Hawthorne Club. A careful record and

chart of the organization, indicating understudies and lines of promotion. A distributing branch of the Chicago Public Library. And finally a definite organization has recently been developed for keeping closer track of employees so that as they develop they will be available for promotion in any department in which there is a suitable vacancy.

This is merely typical of work which is being done in nearly all large progressive companies, as their needs dictate. In the smaller company training will be less systematic, more personal, there will be less or no organized agencies, but there is equal room for intelligent attention to the subject by the company's executives and perhaps a greater chance for contact of the learner with the affairs of the business.

Securing Physical Efficiency.—Practically all measures affecting the personnel have their indirect effect in keeping the employee physically tuned up and ready for his best work. Several special measures bear directly on this result, however.

Plant Housekeeping.—Of these the first and most generally important is what Ordway Tead calls "Plant Housekeeping." Washrooms and toilets should be sufficient in number, light, kept clean, adequately ventilated, and supervised. Floors should be kept swept and each man held responsible for the condition of his work place and given time to clean it up each week. Temperature, ventilation and humidity should be controlled. Sanitary lockers, or racks on which clothes may be hung (the rack being raised to the ceiling during working hours) are necessary. Where racks are used it is a good plan to place them near steam coils so that clothing will be dried on rainy days.

A second feature of the campaign for good physical conditions for the men is the lunch room. This varies all the way from the well-equipped cafeterias of the big companies, where good food is sold at cost, to the provision of a gas plate, coffee urn, and plain bench at which employees may eat. Sometimes hot coffee is provided, or arrangements are made for a

milk company to enter the grounds and sell milk. One company employing a good many women workers ran a canteen and allowed an employee to break off work for a few minutes if she was hungry, and buy and eat a sandwich, a glass of milk, or dish of ice cream.

Safety.—Safety is the next feature on the program. The necessary minimum requirements as to safeguarding belts, fire escapes, floors, gears, elevators, and other points of danger are now matters of law in most states, and are urgently insisted upon by the employer's liability insurance companies. But much additional voluntary work is done by plant safety engineers, such as campaigns to develop habits of carefulness, prizes for suggestions for eliminating hazards, and systematic inspection, both of existing plant and of new installations. Safety work takes two general lines: mechanical protection of danger points, and education and attention campaigns designed to discourage foolhardiness and to keep men on the alert. It is possible to subscribe to agencies which periodically supply striking posters showing the result of neglecting infected cuts, of wearing loose clothing near belts, carelessness in crossing tracks, and other common faults.

Special protection must be supplied at dangerous points, such as ventilation for acid fumes and dusty operations, goggles as a protection against flying particles in grinding and chipping, respirators for gaseous or dusty operations, shoes quickly removable in case molten metal is spilled in foundry work, gloves and similar specialized means of protection.

Medical Supervision.— The third point in the platform of physical efficiency is medical supervision. This is easier for the large company than for a small one, but arrangements can be made for retaining a physician or dentist on a part time or fee basis even for small plants. Sometimes several plants do this work cooperatively. Workmen, especially foreigners, find it hard to secure good medical and dental advice because of their ignorance and fear of high charges, and are often the victims of quacks. The right kind of doctor or

visiting nurse can do a great deal by treating simple ailments or by recommending clinics or specialists competent to treat more complicated ailments, and by teaching right habits of health. An employee will often work at half efficiency as the result of going without breakfast, or an epidemic of colds or grippe may keep a quarter of the force at home. These things the doctor is often able to remedy. Dental work is also sadly needed, and free examination and treatment at cost are valuable aids in physical morale.

Fatigue Study.—A fifth point to be considered in keeping men fit for work is as yet relatively undeveloped—the study of fatigue. We know that fatigue is caused by the burning up of the body's fuel supplies and the accumulation of the products of combustion, or fatigue toxins. We know that time is required for restoring the fuel element, glycogen, to the muscles, and for the washing out and elimination of the poisons. We know that the rate of fatigue accumulation cannot long exceed the rate of restoration without permanent ill effects. We know that fatigue and recuperation should succeed each other in some sort of rhythm. An hour's marching, ten minutes' rest, a day's work, a night's sleep, the week's work, the Saturday afternoon-Sunday holiday,—these are examples of such rhythms. But in the study of the actual ratios and duration of working times not much has been done for specific jobs. We know enough to know, however, that efficiency very rapidly decreases with prolonged overtime work, and that after only a few days of night overtime the worker will do less in ten or twelve hours than he did before in eight. And we know that there is a very intimate relation between fatigue and the mental state of the worker. A tired man is irritable, rebellious, contentious; he suffers lapses of attention in which costly errors or dangerous accidents may occur. Over-fatigue brings with it the craving for artificial stimulus of drink or other excesses as a reaction.

Social Activities.—The provision of suitable outlets for the natural desire of men for sociability is best considered in

connection with other motives in many cases. Thus the mutual benefit association, primarily instituted to provide protection to employees against the financial risk of sickness, may blossom forth in a spontaneous social function as it did in one company where a benefit ball was given to provide funds, or may lead to an unconscious cultivation of a friendly feeling of plant solidarity by the committee which visits sick members of the association, taking perhaps a plant or flowers or other expressions of sympathy. Similarly an instruction class may become the nucleus of a social group or vice versa. Given normal healthy conditions in an organization, social activities are nearly spontaneous, and all that is needed is a suggestion dropped and left to germinate or an unobtrusive offer of facilities to a movement already started in order to cause the development of as much social activity as there is any real demand for. Spontaneity greatly increases the value attached by the participants to any voluntary social contact; in fact, a frequent source of failure of well meant plans for fostering an active plant social life has been the clumsy way in which the management tried to force the matter.

House Organs.—One frequently used method of cultivating interest in the company and a family spirit is by the publication of a plant newspaper or magazine. Mechanically this may vary from a crude mimeographed sheet to the elaborate monthly magazines with colored or rotograve covers, professional illustrations and serious technical articles, issued by some companies. The make-up of a good company magazine will include one or more pages of local and personal items, with plenty of pictures of plant officials, old or specially distinguished employees, new babies, and so on, an athletic column for inter-plant contests, editorial columns in which the management talks things over with the men, cartoons and local humor, descriptions from time to time of big jobs, exhibitions, departmental processes, new products, or technical articles, and for concerns employing women in numbers, a household or dressmaking department.

If at all good, these house organs are usually read by the men with interest, and furnish a valuable means of cultivating good will and enthusiasm. As an illustration of the cost, a sixteen-page magazine, well printed and illustrated, and with cover, was gotten out for approximately five hundred dollars per issue of two thousand copies. The cost could, of course, be made much less or more.

What Does a Man Live For?—The study of the social and human needs of an organization cannot follow any formula. There is in every human being a passionate endeavor for a certain measure of self-expression and realization, for a satisfaction of the deeper emotional and instinctive hungers which lie at the root of all human activities. Security, the sense of advancement, the sense of control of environment, of counting for something, the hunger for praise and appreciation, the stimulus of the competitive game, the joy of constructive creation and artistic expression, the love of mate, the sense of order, justice, and religion—these are among the things by which men live. Not always is it possible for all of these to be fully satisfied, but there is in every man a certain balance of satisfactions, emotional richness of one experience perhaps atoning for the incomplete development or starvation of another side of the individual's nature. In proportion as this balance of satisfactions is adequate, the individual will take pleasure in life and will feel the urge to put himself into his work with joy and wholeheartedness. If this balance is not obtained there comes a point at which the individual asks himself "Is life worth the living?" The answer to this question may be revolt—quitting the job—or in deeper-seated, more incurable cases, failure or even suicide. Or the answer may be an attempt to supply the hunger by the artificial stimulus of dissipations, or, none of these being possible to the individual, his personality may be crushed beneath the leaden weight of circumstances, into a sodden apathetic acceptance of a hopeless situation.

There are many things in factory work which run contrary

to human instincts. The deadly humdrum of daily dependability, so necessary to effective production, is in itself galling to the neck of the man whose ancestors but a short span of years ago, as history goes, were free nomads, and who still feels occasionally the urge for adventures in new fields. And on individuals of only ordinary capacity, the strain of modern life, of the support of a family, the uncertainties of unemployment and of illness and old age, tend to force a preoccupation which gradually crowds out of life all the spontaneous play elements which should enrich it, with a consequent immense loss to society of motive force, of imagination and daring and desire to excel and to achieve. The ranks of industry are full of the men who, thus starved, perhaps to the point of rebellion, are unable to put into their work the zest for accomplishment which is natural to men, or who cherish bitter resentments which they cannot explain correctly even to themselves, since the cause is emotional rather than logical. It is from the ranks of these men that the revolutionist comes, it is to such men that the challenge "Workmen, arise, you have nothing to lose but your chains" appeals with a sense of bitter accuracy.

Some part of this maladjustment of industry to the individual it is difficult at once to remedy. Organization has evolved more rapidly than the individual. It requires, in the extreme functionalization of today, in the tendency toward even larger and more complex operating units, adjustments which yet irk the individualistic, impulsive nature of men. We have not yet bred a race of worker ants. Most of us are thankful that society is still looked upon as a means for the advancement and perpetuation of the individual, rather than the individual as a means to perpetuate society.

But however fundamental and perhaps inevitable are certain tendencies of industrial development in their relation to men, it is nevertheless true that in a hundred ways a totally unnecessary strain may be put on the worker in the ordinary relations of the factory. He hungers for praise, for recog-

nition of his individuality and its worth; and he may be contemptuously ordered about by a number. He is sharply reprimanded for taking a day off fishing, unannounced, and indeed it would be proper to ask his foreman first. Yet he knows that any moment he may be told casually "no work tomorrow."

Making Factory Work a Career.—The list of illustrations of unnecessary blows to the spirit of the workmen would be a long one. The really great task of the personnel man is to rightly and sympathetically interpret hopes, desires, and aspirations of the organization, to use social activities, stock purchase and saving plans, insurance, pensions, intelligent and tactful disciplinary rules, payment and incentive plans, or whatever the means may be, in one grand ensemble for the harmonious advancement simultaneously of the company project and of the employee's happiness—truly a big task, and one not solved by sweeping and dramatic actions so much as by unostentatious day-to-day tact and good sense. Gerard Swope, president of the General Electric Company, says regarding the company's attitude toward the public, "What I mean by service is the value of an enterprise to the community. It is not necessary to be altruistic about this. A serving business does not have to bother about being altruistic. The community is willing to pay adequately for a job well done." A similar philosophy may well serve as a basis for the internal industrial relations of a plant. Making work a career, an adventure, to men, pays. In the choice of means for this result it will in general be found that the effective means are ones naturally a part of the task, rather than the paternalistic "welfare" schemes which have so often been unsuccessful because the employer could only see them from his own attitude as a resounding act of generosity, a monument to foresight and liberality, and could not see them from the worker's standpoint, as something foreign to his desires and perhaps an affront to his sense of independence. Men in the main look upon their job as the business side of life. Joy in

work comes in the main from the sense of good leadership, of accomplishment, of personal progress, of security, of team work. Evidently the responsibility for the intelligent leadership which will make these things possible goes much farther than the personnel department. One element in good human relations is the feeling of smooth, successful progress and achievement. A reorganization of production so that foolish losses and inefficiencies are eliminated, and the men given a clear track for the best that is in them, may do more for the development of a good esprit de corp than a host of welfare plans. A second element in good relations is the connecting up of the man with the common purpose. A sales competition in which the salesman sees his company "whoop 'er up" with substantial profits while he gets nothing but praise, inevitably leads to cynicism and bitterness. It is here that the personnel man may be of use, with his more sensitive appreciation of the workman's point of view and his greater detachment from production and cost.

The adjustment of social activities to the general plan of making the plant activities as a whole better fit the emotional life of the employee, involves naturally a somewhat sensitive appreciation of just what these needs are. It is the writer's belief that with the majority of men, except perhaps in special cases such as isolated communities or new men, the needs for society are pretty well satisfied by the man's outside connections, his lodge, church, neighborhood and social set, and that social activities in the plant should in the main be incidental and directed towards better acquaintance, the relaxing of tension and the development of team spirit. Picnics and athletic events are nearly always welcome.

Financial Assistance.—Here also any plan must be reviewed from the standpoint of the employee, sensitively resentful of any affront to his independence. Here also, outside of the responsibility for those who have grown old in company service or who have been incapacitated in the course of this service, the test of profitableness to the company is a

wholesome check on extravagant and undesirable plans, when profit is measured in a broad-minded way.

Nearly every company which has operated for any considerable period is faced with the problem of the pensioner, who has given the greater part of his usefulness to the company and is no longer able to compete with younger men. In part these men may be assigned to easier work suited to their declining powers, in part they may be given a pension. In one representative plan the pension was computed as a certain proportion, say two per cent, of the average income for the last year of service, multiplied by the number of years of service, the pension being open to men of sixty-five or older with twenty years or more of service with the company. Frequently it is stipulated that this service must have been continuous except for lay-offs on account of lack of work by the company.

The problem of loss of service due to sickness is usually answered by an Employee's Mutual Benefit Association, which is supported in part by fixed assessments on employee members, in part by company contributions. The associations are usually administered by employees, physical examination is required before admission, membership may be voluntary. A regular scale of benefits amounting to about half the weekly salary is paid for every week of illness after the first, either for a period of say thirteen weeks, or for the full duration of the illness. Sometimes a death benefit of one hundred dollars is paid the family in case of death.

Loss of time and expenses, due to accident resulting from the occupation, are in most states taken care of by employers under compulsory employees' compensation laws, and it is common practice to turn the whole responsibility for such compensation over to insurance companies, whose premium is a certain per cent of the payroll for the period.

Group insurance, under which every employee is insured for the period of his employment for five hundred or a thousand dollars or more, is another plan sometimes used. Needs for

temporary financial assistance may be met by a revolving loan fund, the money not being available for new loans until repaid by previous borrowers. Free legal advice and assistance in drawing deeds, etc., are sometimes offered to employees. Sometimes the purchasing department buys staples such as potatoes, coal, etc., in quantity and offers them to employees at cost including handling, sometimes doing this intermittently, sometimes through a cooperative company store. Many companies have special plans by which stock in the company may be purchased under favorable terms by employees. The company may also in many cases assist employees to finance homes, or may build and rent or sell homes, in districts in which housing is inadequate.

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CHAPTER XVII

WAGE PAYMENT

In dealing with this subject the manager is called upon to consider first the general level of wages, second the selection of a system of payment which shall secure a proper relation between compensation and effort or skill, third the machinery for concluding a bargain with employees.

Various theories have been put forth as to the proper basis for determining the absolute amount of the wage, such as by a cost of living formula. The general level is in actual practice determined by the operation of the law of supply and demand in a very sensitive market. Artificial control is possible and is from time to time secured either by labor or capital by the creation of monopoly conditions. The time necessary to learn a trade acts as a drag on complete fluidity between occupations and the reluctance of employers to incur the disorganization and loss of good will incidental to a general wage reduction, also retard adjustment. But in general, shortage or surplus in any one trade or locality quickly makes its influence felt in other lines, by draining off or pouring back into the trade the most fluid elements, and thus creating indirectly a shortage or surplus which affects the whole trade.

It is the personnel manager's task to follow these market changes. To do so he has available the indications given by his own company's rate of turnover, indicating when the wage level is becoming insufficient to hold men in the face of outside competition. Figures in certain basic industries and occupations such as the building trades, common labor, etc., are also common knowledge or are easily available, and direct

exchange of information between employment managers, as to rates on typical operations, is also possible.

Usually a company may vary quite a little above or below the market and still obtain enough men to run the plant. Paying slightly less than market is sometimes possible to larger industries which are well advertised, and attract employes because of their size and because of many special social facilities and other advantages which are more easily arranged for by the large company than by the small one. But in general the policy of paying low wages results in rapid turnover of force and in a negatively selective process which tends to retain the least ambitious and competent employees. It is usually more profitable to err on the other side, making the position sought after by good men, and valued by the incumbent when obtained.

Systems of Payment.—The making of a wage bargain is in reality a very complex adjustment of a great variety of variables. To the employee, the wage is only one factor, although an important one, in the sum of the satisfactions he secures from his job. It must, if he is to remain a satisfied employee, be adequate to maintain him in his usual scale of living, and it is valued for the implied recognition of ability which it confers. It is, however, supplemented or counterbalanced by consideration of the steadiness, security and prospects of advancement of the job. It is considered in connection with the disagreeableness or pleasant nature of the job and the current social rating of the work. Ability for ability, "white collar" men can nearly always be had cheaper than manual laborers.

From the standpoint of the management the wage is supposed to buy output, technical skill, time, loyalty and interest in the work and company profits, and a variety of other factors, some perfectly specific and measurable, some quite intangible. Management's problem is to find a system which will closely correlate payment with these desired results.

For this correlation the first essential is a unit of measure-

ment of output, and the great importance of time study is that it helps to remove guesswork from the measurement of output. A "fair day's work" is not a sharp division between the sheep and the goats. It is rather some point in a long range of values between indifferent inattention or deliberate soldiering at the one extreme and feverish, injurious activity at the other extreme. It varies between individuals and at different times of the year; it is affected by local conditions such as lighting, good scheduling, upkeep of machinery, and presence or absence of good plant morale and leadership. The exact determination of the point in the scale which is a fair day's work is obviously a difficult task, involving correction for many factors, comparison and averaging of many individuals, frequent adjustment to changing conditions. The habit of work varies between plants, one working faster as a whole than another. The use of correct time study methods, however, makes possible a reasonably close approximation to a correct standard, the effectiveness and range of comparison being greatly increased by the use of Taylor's system of analysis into unit times.

Another problem in compensation is raised by the need of paying for varying and sometimes counteracting factors. Thus in piece work output may be obtained at the expense of quality. In the foreman's work a long list of varied activities would have to be measured.

The systems of payment devised to meet this problem of adjustment of compensation of effort may be roughly divided into three classes: compensation on a time basis, compensation on an output basis, and a somewhat miscellaneous group in which, as in profit sharing, some other principle than these two determines the wage.

Time Basis of Payment.—Illustrations of the time basis of compensation are furnished by the hourly wage or weekly, monthly or annual salary. In this system, adjustment of pay is made on the basis of the judgment of the superior, who recognizes good work by promotion or increases. The system

has the advantage of great simplicity in the accounting for time and making up the payroll, and of great flexibility in allowing emphasis to be placed on varying and complicated requirements. It is almost the only system available where standard times are impracticable of measurement, as in development work, special operations, executive work, etc. It may be a very effective system of securing effort, where other means of stimulus are strong, such as interest in the task itself on the part of executives, research men and similar high caliber men, or close supervision and good morale with more routine workers. Since time is the unit which the workman has to sell, the other systems such as piece work usually start with a "base rate," which represents the usual time rate for the particular grade of employee, and so adjust the piece rate that, working at the standard rate, the man will earn the base rate, or more usually twenty to twenty-five per cent above the base rate. The extra percentage is in the nature of compensation for the greater effort expected.

Output Basis of Payment.—We may subdivide the plans of payment for output into groups, one the straight piece rate plans, in which the man receives a fixed sum per unit of output, the second group including many and various plans such as the Halsey premium plan, Gantt bonus, Emerson bonus, and other systems in which the time rate is combined with a bonus based on production.

Among the various forms of straight performance payment are piece rate, commission payment to salesmen, and some of the so-called profit sharing plans in which payment is based on the profits earned by an individual or a department, measured in output.

It is possible to include more than one element in the compensation. Thus one company, to reduce the waste of material due to careless work, used a "quality" piece rate, one rate being paid for a certain percentage of material obtained as accepted finished work, with rates increasing by graded steps for higher percentages of utilization. Babcock, in "Taylor

Kani

System in the Franklin Shops," introduces a somewhat complicated but interesting formula in which an attempt was made to evaluate and consider in paying a long list of qualities, services and factors, such as output, quality, versatility, length of service, regularity of attendance, cost of living, etc.

For jobs in which it is feasible to maintain standard conditions there is probably no system better than straight piece rate, with standards set in accordance with the best practice. Accounting and preparation of the payroll may be made comparatively simple, payment often being made on presentation of some sort of a check or ticket sent out with each batch of work, which is O. K.'d by the foreman and retained by the man. A large element of uncertainty is removed from costs by this system. Piece work puts the burden of performance on the man and makes his earnings dependent on his own energy and skill, thus noticeably improving discipline and furnishing a spur to ambition. And the system is simple, traditional, and easily understood and computed by the men. On the other hand, under this system the original setting of the rate becomes a matter of great importance and mistakes have a serious result. Where rates are guessed at by the foreman, as is the case in many shops, an almost universal difficulty is that the rates are set too high. The men on going on piece work speed up as compared with the slower day work pace and are soon earning wages out of all proportion to the usual pay for the work. Then comes the inevitable cut, then the inevitable attempt on the part of the men to protect the rate by limitation of output. Much of this difficulty can be eliminated by careful setting of standards.

The bonus plans were evolved in an attempt to eliminate this basic weakness of the inaccurately set piece rate. One of the earliest of them was the Halsey system in which the best existing record of performance time, or a time determined by time study, was taken as a standard, and if a man was able to do the task in less time, the saving over standard time was divided between management and men, equally or

in some fixed proportion. Thus if the standard time of performance were fixed at six hours, and a man working at fifty cents per hour accomplished the task in five hours, with an equal division of the saving between management and men the man's earning would be:

Day rate for 5 hours @ .50............	$2.50
½ of the hour saved..................	.25
	$2.75

This system may be applied using a standard time fixed by time study or in any other way. It tends to automatically reduce the cost of the work as output increases, while increasing the hourly wage of the man. This system has the advantage of greater flexibility than the piece rate in meeting variable conditions, since the man is guaranteed his day rate in case irregular supply of materials, etc., prevent his performing the task in standard time.

Emerson and Gantt have proposed systems in which the man receives a fixed bonus, say 20% of the standard time earnings, per piece, if the work is done in standard time or better. In the Gantt plan the man receives straight time pay until he reaches the standard, then receives, as long as he maintains standard or better, a straight piece rate 20% higher than the day rate.

Thus, under the Gantt plan, if standard time were fixed at six hours, at fifty cents per hour, and the man did the job in five hours he would receive:

Pay for standard time, six hours.......	$3.00
20% bonus	.60
	$3.60

If he did it in seven hours he would receive only the standard hourly pay or $3.50. Gantt also proposed the plan of giving the foreman of a gang a bonus when all the men in his group were earning bonus. The history of an installation of this system, with very interesting charts of improvement of output, is given in Gantt's "Work, Wages and Profits."

Emerson modified this system by bridging the gap between the man's usual operating efficiency without bonus and the standard performance. The performance of the man on day rate only might be from a half to two thirds the standard performance. As an encouragement to the man to whom the standard would appear too high a mark to shoot at, Emerson offered a small parabolically graded bonus, beginning at a fraction of a per cent at two thirds of standard time and continuing by increasing steps up to 100% performance, at which point a 20% bonus was paid as in Gantt's system. Emerson's scale of preliminary bonuses is often modified in practice in the interest of simplicity; thus bonus may begin at 81% of standard and increase by 1% steps for each per cent of increase, 1% bonus for 81% efficiency, 2% for 82% of standard, and so on.

Gang Payment.—A modification of the plan of individual payment which may be applied with advantage in some cases, is the plan of payment of a fixed sum to a group of workers for the completion of a given task. This is frequently used on assembly jobs where a group of men performs the same operation continuously as a group. Under this plan the total payment is divided among the men in fixed proportions agreed to among the men themselves or in conference with the management. W. L. Churchill, in *Management and Administration*, the August, 1923, number, suggests an application of the Halsey bonus system in this fashion. The group may be a gang or a whole department, and the task is fixed as the best previous normal time or cost of performance. Any savings made during a current month by the department or group are credited to the department in terms of hours, while any losses as compared to standard are charged on the same hour basis. A bonus, in this case of two thirds of the month's savings, is then divided among the members of the group. The same system was applied in the case of savings of material, where, for example, in cutting leather a standard percentage of utilization of hides was fixed, and a bonus, in this case 50%

of the saving, was paid for all utilization better than the standard percentage.

This plan, except for the group payment feature, bears some resemblance to a plan of gain sharing used by Schwab at the Bethlehem Steel Company's plant, under which each individual, from president down, so far as practicable received a proportion of his pay in the form of a bonus for savings made over the previous record of the department, these savings representing, in the case of executives, the total saving or gain of the department as compared with the previous record of the department. In the case of a workman, the saving would be his individual increase of output over the previous standard.

The outstanding advantage claimed by Mr. Churchill for the gang bonus plan, as shown in operation, is the modification of the everybody-for-himself attitude engendered by piece rate and the development of a more cooperative spirit. It shares in another advantage of the bonus plans, namely, the fact that since the standard is fixed in terms of time rather than money, wage rates may be changed in accordance with prevailing market levels without affecting the standard times.

An additional feature of the system is the fact that special, temporary bonuses may be offered, without prejudice to the standard rates, for completion of emergency rush jobs, handling of troublesome lots of material, etc.

Distribution of the bonus is made monthly, as a simple percentage added to the regular earnings. In some cases, by agreement of the men, a portion of the bonus is held out as a reserve for periods of no bonus, or for use for sick benefit funds, group life insurance, etc. To operate effectively it would probably be necessary to make the average group or department unit of distribution small enough so that each member in the group was in daily contact with the others, and thus subject to the stimulus and moral pressure of the group, which would counteract any tendency to take it easy and let the other fellow earn the bonus for him.

Many other systems have been proposed, some very elaborate. Probably for the majority of cases straight day rate and piece rate are the best systems. The bonus plans find a special application in cases where standards are tentative or roughly approximate, guaranteeing the man day rate in case the standard proves too difficult, automatically reducing the rate on the other hand, if the opposite error has been made.

So much depends on the intelligence with which the system is applied that almost any system can be made to work and yield passable results in the hands of a good management.

Profit Sharing.—The third general class of payment plans named was a miscellaneous class in which payment was based on other factors than time or performance. One of these otherwise unclassifiable plans is profit sharing. Under this plan, which of course is found applied with many variations, the management usually agrees in advance to share profits with employees, according to some previously agreed plan. Thus a "dividend to labor," a percentage of earnings equal to the dividend percentage, may be paid, or one half or one fourth of the total net profit for the period may be divided. Usually the method of distribution is as a simple proportion of wages, but the proportions may be varied as between various classes of employees, foremen, salesmen, etc., or a committee may be empowered to withhold or increase payments in accordance with a scale of points for attendance, cooperation, etc.

A modified plan sometimes called limited profit sharing is really only the Halsey plan under another name, the salesman, for example, receiving a share of the increase of profits on his business, or a department head a share of the savings made by him in the operation of his department.

The consensus of experience seems to be somewhat against profit sharing. While the expectation of profit sharing seems to exert an influence toward good feeling and toward the conservation of company material, etc., the effect of his own efforts on the amount received by the individual is so vague, his

efforts have so little effect among the efforts of many, that there is little stimulus to effort. Further, the systems of distribution are often elaborate, demanding an inspection by the men of the general accounts to convince the men of good faith on the part of the management, and the men, having accustomed themselves to the higher income, are discontented if it is necessary to pass a distribution during a lean year. Probably the persistent interest in profit sharing, in spite of its long history of dubious success or failure, is due to a desire to find some basis for a true partnerhip of labor and capital in industry, as much as to the merits of the plan itself. It is doubtful whether workmen desire as a body to participate in the hazards of the enterpreneur. John R. Commons voices the thoughtful opinion that workmen as a whole prefer to let management manage and take the risk, and to make the best bargain they can for their labor. In other words they prefer the amicable relations and "good will" which exist between seller and customer to the cooperative relation.

Many proposals have been made for a partnership in industry. Directors have been elected from the men in the shop, for example, but unless exceptional men they come into an atmosphere and a financial technique totally foreign to their experience, are apt to be overawed and to become more or less negligible factors. The sale of stock to workmen is a plan of greater promise, used on rather an extensive scale by many corporations, such as the United States Steel corporation. Favorable terms of purchase and protection against market declines are usually offered to employee purchasers, with a provision giving the company the option of repurchase if the man leaves its employment. While the sale of minority holdings appears desirable from every standpoint, certain dangers enter when the men acquire substantial voting strength. These dangers arise from the possibility of outsiders buying up a controlling interest and from the financial inexperience and instability of the workmen. The works council plans, to be later discussed, seem to offer a very practical combination

of an explicit forum for the debating of differences between management and men, and of an implicit conference, in the field in which the opinions of the men are competent, for a discussion of common problems and interest.

Included in the third group of wage plans may be placed also such detached plans as the giving of arbitrary bonuses at intervals, the "sliding scale" plan of payment used in the iron mining industry, in which wages go up or down with prices of the product, and other plans.

Procedure in Paying.—The mechanism of payment has already been partly described, but will be reviewed to give it unity. On his acceptance as an employee the man is usually given an employee number, and thereafter he daily records his time of entrance and leaving under this number, punching a time clock, or passing a check in at the gate as he enters the shop before starting time. This time is posted to the payroll record, and at the end of the week or other pay interval is totalled and in the case of time rate workers is extended at the hourly rate. Where job time cards are made out, these are sorted by days and checked with the clock record as a verification of attendance. In the case of piece workers, a similar procedure is followed, except that the time card, showing the rate per piece and number of pieces, with foreman's O. K., is extended, the piece work earnings posted, and the record totalled as before.

Payment by check is more convenient to the management, but workmen do not in most cases find it convenient to cash checks, and there is a temptation to cash them in saloons or by other uneconomical or questionable means. It is better practice with manual and minor office workers to pay in cash. Envelopes are made up from the payrolls, the required amount and denominations of currency are ordered from the bank and "stuffed" into envelopes and the paymaster, with guards if the amount is large, proceeds from department to department. In each department the foreman stands next to the paymaster, receiving the envelopes in order of check number and calling

Payroll for department..........Week ending...........19...													
Empl. No.	*Name*	*Time or P. W. Earnings*							*Total*	*Rate*	*Over-time*	*Total Paid*
		M	*T*	*W*	*T*	*F*	*S*					
	Amt. brought forward...											
	Total carried forward..											

Fig. 67.

PAYROLL FORM.

off the employee's name and identifying him. If a man is absent his envelope is retained and held subject to his call at the timekeeper's office.

Figure 67 illustrates a form used in compiling the payroll.

An investigation conducted in 1918 by the Western Efficiency Society, and summarized by permission in Figure 68, gives some idea of prevailing practices in paying wages.

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Questionaire Conducted in 1918 by the Western Efficiency Society, Covering the Practice of over 100 Representative Firms.

	Percentages			
	a	*b*	*c*	*d*
1. How do you pay—(a) cash (b) check (c) both. "We pay cash to shop employees and to other employees receiving less than $25 per week." "Cash does not reveal earnings to outsiders."	57%	21%	22%	
2. How often—(a) daily (b) weekly (c) bi-weekly (d) monthly. Weekly payments preferred.	1%	68%	25%	6%
3. Do you pay in full—(a), no; (b), yes. (Tuesday a pay day for preceding week is predominating method.)	60%	40%		
4. Hold-outs. "A hold-out of a portion of the wage for the purpose of reducing labor turnover does not so result. Increases unrest, is usually illegal."				
5. Do you cash pay checks or do employees get them cashed elsewhere?—(a) cashed (b) elsewhere. "When we changed from checks to cash three saloons closed in the vicinity of the factory."	43%	53%		
7. Experience with piecework payments. (a) Satisfactory (b) unsatisfactory (c) no experience.	54%	3%	43%	
8. Experience with bonus or premium payments—(a) satisfactory (b) unsatisfactory (c) no experience. (10% service bonus for attendance often used.)	42%	9%	49%	
9. Experience with straight salary—(a) satisfactory (b) unsatisfactory.	43%	57%		
13. Experience with profit sharing plan—(a) satisfactory (b) unsatisfactory (c) none. "Very successful with important men directly influencing cost and production."	5%	16%	79%	

FIG. 68.

METHODS OF WAGE PAYMENT.

CHAPTER XVIII

INDUSTRIAL RELATIONS

Theories of Industrial Relations.—It may perhaps be well to preface the discussion of collective bargaining by a further brief outline of the philosophies of ownership mentioned in the preceding chapter, since any plan adopted is colored by the theory of ownership of those adopting it. Reviewing briefly some of the more general theories we find first the old *paternalistic* theory, the belief that under the Divine plan some were destined to rule and others to serve. Usually there went with this philosophy a complacent acceptance of conditions of poverty and exploitation which are shocking in the light of present-day standards. Modified by the impact of a developing sense of social responsibility, and of other theories, this theory is still held in a modified form by many who sincerely believe that society is better served by the wisdom of its leaders than by the wisdom of its masses—that society, as Emerson and Carlyle put it, rests on the shoulders of its heroes and its great men.

Fundamentally opposed to this, the old idea of autocracy, we have the modern theory of *democracy,* and for the attainment of democracy we have to-day many programs and a multitude of voices. Most extreme of these is the proposal for the socialization of industry—its ownership and control by all, or in the case of the bolsheviki, by a particular and heretofore downtrodden proletarian class. Many modifications of this central idea exist.

Intermediate between socialism and private ownership is the plan of *consumers' cooperation* extensively applied as the Rochdale plan in Europe, where in some states a large share

of all business is done through coöperatives, and attempted in a number of instances in America, where its operation has not been as successful. Briefly, in a consumers' cooperative a group of consumers, say in a neighborhood, contribute capital for shares in a company, which buys and sells, manufactures and performs any of the productive functions, returning to its shareholders the profit made at the usual competitive price at which the goods are sold.

A third general attitude, which does not seem to share the fundamental weakness of the socialistic premise, namely, its disregard for the inherently individualistic and selfish nature of man, is what we may call the *buyer and seller attitude.* This theory is very clearly expounded by John R. Commons in his book "Industrial Goodwill," and essentially it is a proposal that labor and capital shall meet on equal terms, all the laborers in one industry as one unit and all the employers as another. Frankly recognizing a conflict of interests at the point of price, yet also recognizing a community of interest in the need for employment and expansion of business, these two are then to meet and make the best bargain they can, a bargain which will favor now one, now the other, according as economic forces operate to give one or the other a strategic position.

This seems accurately to present the attitude of organized labor today. It does not desire management, being quite content to forego the risks and profits of ownership in favor of the assured income for doing the thing it knows how to do. Certain exceptions to this are found, in the tentative engagement of some of the larger unions, such as the Brotherhood of Locomotive Engineers, in manufacturing and banking.

Ultimately the corollary of a mutual agreement of the two organized branches of a trade is a bargain at the expense of the unorganized public. Can the laws of supply and demand, the substitution of other and competitive products, be depended upon to check the natural selfishness of the trade group? It is at this point that we strike one of the

knotty problems of modern industrial life. Probably for the luxuries, the lesser articles of life, competition is sufficiently free to do this, yet such crises as the long series of defiantly engineered coal strikes, the transportation strikes in Great Britain, the threats of railroad strikes, the policemen's strike in Boston, indicate how completely at the mercy of a group may be a public which has adapted its scheme of life to a particular utility. A new code of ethics and laws, a system of Federal regulation, appears an almost necessary corollary of the ever more comprehensive organization of capital and labor.

It is significant to note the constantly increasing urge to collective action of one form or another which underlies all these modern theories. The benefits and the necessity of group and organized action of some sort seem to have passed beyond the stage of theory. It is, in the degree exacted by modern life, a new lesson to be imposed on the naturally impulsive and individualistic nature of man.

Collective Bargaining.—The specific method of reaching the agreement between capital and labor referred to in the preceding paragraphs is well exemplified by the method of collective bargaining used by the Men's Garment Trades. The Amalgamated Clothing Workers of America is a union of clothing workers which originally was recognized and dealt with only by the firm of Hart, Schaffner & Marx of Chicago. The system of negotiation there worked out proved so successful that when the great wave of unrest and organization of the war years struck the clothing industry, membership of the Amalgamated became national in scope, and the employers also organized and adopted the same general plan of negotiation. Under this plan an agreement covering wages and working conditions for a period of three years is drawn up between negotiators chosen for each side. This agreement covers such items as the scale of prices to be paid for various classes of work, the hours of work per week, rate of pay for overtime, preference of union workers, regulations as to work-

ing conditions and discipline, provision for the furnishing of employees by the union as required by the employers, and provision for the organization and operation of machinery for administering the agreement.

There is a constant need for the interpretation of the agreement in specific cases in which an injustice is claimed by one side or the other, for the setting of new piece rates, and for carrying out the conditions of the agreement. To meet this need a trade board was appointed for each regional group, consisting of an equal number of representatives from each side and of a paid impartial chairman chosen by both sides. Usually each factory had its company and labor representative, although in the case of smaller factories one man might represent several factories. This board, meeting at regular intervals or on call, was empowered to reach agreement on any matter in dispute. A Board of Arbitration, however, was also provided for, to which appeal could be made by either party from a decision of the trade board.

Each member of the trade board, on either side, was provided with deputies, usually men with other duties in the particular shop, the union deputy a workman elected by the union men, the company deputy a local labor manager or other company official. The procedure in case of the arising of any dispute was then, first, its submission to the local deputies, who if possible composed differences and reached an agreement mutually acceptable to men and foremen. If this failed the case was filed with the secretary of the trade board, heard and decided, with an appeal to the Board of Arbitration in case of a failure to agree to the trade board decision.

In practice the trade board became the working unit of the system, and the impartial chairman, having the casting vote, became the key man of the system. Experience has been that the chairman usually was fair, but that in order to retain his influence with both parties and also to support friendly labor representatives with their own constituencies, there was a tendency to give a decision first to one side, then to the

other, and to compromise decisions rather than clear-cut facing of the issue. This general description may be taken as typical of collective bargaining in the industries in which it exists, save that the machinery for administration is more complete in this case than is generally the case. It is interesting to notice the tendency to build up, in a particular trade group, a body of decisions and precedents which bears a close analogy to the common law which is the foundation of civilian relationships.

Works Councils.—The union collective bargain can hardly be taken as representative of the whole of American industry. It is only in certain industries that the union has attained a strength sufficient to enable it to dictate this plan of negotiation. While no intelligent man questions the right of the workingman to organize for the advancement of his interests, it appears to be equally the right of the employer to deal with his employees as individuals where this is possible, both rights being subject to the superior right of the state to prevent violence and to protect the individual in life, liberty, and the pursuit of happiness. Many intelligent employers of non-union or of mixed labor have, however, recognized,—especially in the enormous impersonal units of modern industry,—that the old method of individual bargaining is no longer adequate as a channel of contact between management and men. There are too many intermediary subordinate officials, too many obstacles, and a high potential voltage of discontentment and rebellion may accumulate until it discharges in the destructive lightning of a strike or other labor trouble. Some easier channel of communication, some industrial lightning rod, is needed to conduct the cause of discontent harmlessly away before it has accumulated a dangerous potential. The works council, a comparatively recent plan, has proven itself a very effective means of bringing workmen and management together for the direct expression and settlement of these petty personal grievances, which records show are back of nine out of every ten labor troubles. A shrewd and sympathetic ob-

server has said that the average body of workmen sometimes strikes first and then hires economists to provide it with an issue. Outside the highly organized unions which have learned how to conduct a deliberate campaign for self-advancement, it is probably true that labor troubles are more often due to personal affronts to workmen, sympathy with other workmen, and similar apparently local and petty things, but which touch a man where he is sensitive, than to the more basic economic questions such as wage levels.

Non-union collective bargaining is of two prevailing types, the works council and the company union, the former being the predominant type. Comparatively few companies have used the company union. Under this plan the employees are encouraged to form a local, unaffiliated union including all workers, which elects its own officers, holds periodical meetings attended by all, and deals with the company through its elected officials.

Under the works council plan in its typical form elections are held periodically among the men, and representatives are chosen who meet monthly with an equal number of management representatives to discuss any matters of common interest, such as wages, hours, and working conditions.

A Typical Council Plan.—The plan used by the International Harvester Company may be taken as typical of works council procedure. The following are the principal features of the plan.

(1) One employee representative is elected by each group of two or three hundred workmen, to serve one year in a local or plant works council. The management appoints an equal number of representatives among its foremen and other supervisory employees. Provision is made for the recall of representatives, upon petition and vote of the respective constituencies. Detailed provision is made for districting the shops, for the conduct of elections and the qualifications of voters and representatives.

(2) The monthly (or more frequent on call) meeting of

the council is presided over by a president and secretary, both company representatives, but without vote in the proceedings. Any employee failing to secure satisfaction of a grievance, with his foreman, may submit it to his local representative or to the secretary of the council, when it will be placed on the order of business and discussed and settled if possible in council. Not only grievances, but constructive suggestions, discussion of operating improvements, announcements of policies by the management, may be brought before the council. Each side, management and men, votes separately on any controversial question, and the vote of each side is then taken as a unit, evidently requiring a majority of each side to carry. The decisions of the council are made in the form of recommendations to the superintendent or plant manager, who is expected either to carry them out or explain to the council representatives the reason, if he considers it inexpedient to do so.

(3) In the latter case the matter may be referred back to the council, and appealed to the president of the company. If the president considers the matter of general interest to all plants, he may then call a general council composed of representatives sent by each local council. The general council functions in the same way that the local council does. If the matter fails of decision at this stage the president may then, at his option, submit its settlement to arbitration. It will be noticed that at no stage does the management relinquish its final power of decision, up to the final voluntary stage of arbitration. On the other hand, an intelligent management (such as that of the Harvester Company certainly is) would be very slow to risk charges of lack of good faith and the undermining of prestige of the council by obstinately refusing fair play. The plan has a very successful history, not only in the case described but in some hundreds of other cases, of companies both large and small. Many variations are found, such as an attempt to follow the Federal Government and provide a House of Representatives, Senate, and Cabinet, but

the general plan described seems to have the widest adoption and greatest success. Considerable difference is also found in the degree of surrender of control by the management. In some cases decision of the council is automatically binding upon both sides, the management taking its chances of protecting its interest along with the men. In other cases such as that described, while wide powers are given to the council, the power of final decision or veto is reserved to the company. In other cases, such as the Employees' Representation Plan of Swift & Company, the council is simply a forum in which management and men meet to discuss and peaceably compose their differences if they can, either side retaining full freedom of action to strike or use other direct action if negotiations fail.

Figure 69 illustrates the channels of appeal provided for in another works council plan, used by the Peoples Gas Company of Chicago.

Compared with the plan of union collective bargaining, the works council plan has a distinct advantage in the more constructive trend given to its meetings. These are not merely outlets for the airing and perhaps encouragement of grievances; they are dedicated as well to the constructive problems of the industry, and experience shows that they are in fact effective forums for the discussion of these problems. As one writer has said, the union workman comes to the collective bargain in the attitude of the consumer rather than that of the producer, he is interested in what he gets rather than in what he gives, and may come to give as little and get as much as possible. There is a danger, unless the council plan is very well handled, that the representatives of the workmen will become unduly sympathetic with the management's point of view, and thus lose contact with their own constituencies. All in all, however, the history of the works council is one of great success and promise.

A few council plans have failed. The plan would probably not be advisable in a plant where the average intelligence of

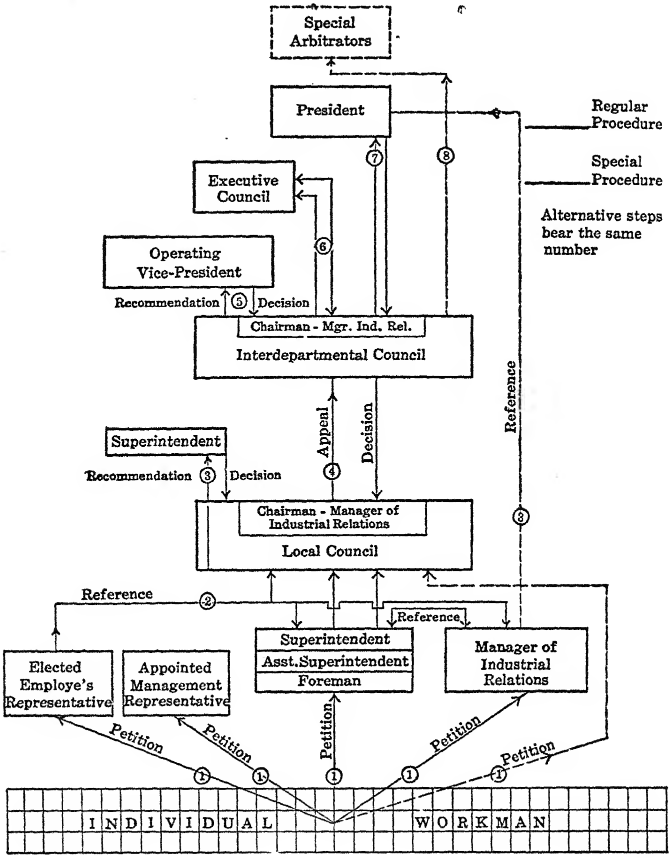

FIG. 69.

CHANNELS OF APPEAL, WORKS COUNCIL PLAN.

the men was low. It should not be necessary in a small plant with an intelligent executive already in effective contact in less cumbersome ways with his men. It would probably not be well received if it was attempted to force its use as a substitute for an existing plan of union recognition.

Labor Turnover.—Some method of measurement of the results of any particular labor policy being a desirable thing, the measurement of labor conditions by the turnover of labor has become a standard procedure. Labor turnover may be defined as the ratio, for a given period, of the number of workers leaving the payroll (separations) to the average number on the payroll for the given period. The period may be a week, month, or year, although comparisons are most easily made over a yearly period. The separations again may be divided as between avoidable and unavoidable, the unavoidable including such causes as death or illness, leaving town, marriage of women, etc. The formula including these factors may then be stated as follows:

$T = \frac{S - U}{P}$ where T represents turnover, S, total separations, U, unavoidable separations, P, the average number on the payroll. This average may be the daily average, or more approximately the average of those on the payroll a particular day each week or month.

The turnover concept should not be made a fetich. It is a good general indicator of symptoms in labor relations and a rough measure, by the increase or decrease of turnover, of the efficiency of any particular policy or labor department. Its showings are complicated by so many outside factors that any conclusion drawn from it as to specific results should be used with a certain degree of caution. It affords a rough method of comparison between industries—very rough usually, however, because what is a normal rate for a factory using one class of workers might be extremely low or high for another, and a normal rate in 1918 would have been a high rate for most factories in 1921. One hundred per cent turnover is not an uncommon figure, although many industries have much less, some much more. The turnover figure may well be used as costs are used in the test run system, being computed intermittently as some element seems to demand attention, or in order to give an occasional check on general tendencies.

An analysis which goes back of the turnover figure for the factory as a whole is of interest. One classification which should be made is by departments and individual foremen. Often this analysis will furnish confirmatory evidence of the fact that some foreman does not know how to handle his men or has had some special difficulty with them.

Another interesting classification is by length of service. It will almost invariably be found that the rate decreases very rapidly as the period of service increases, so that most of the turnover comes during the first six months. This points to the importance of careful selection of the man by the employment department, and of taking pains to get him started happily in his work. It was found in the experience of a vestibule school, training women who had never before done factory work, that when the task given the first morning was a complicated one which could not be mastered immediately, many of the women would not show up after the first half day's work. When the task was broken up into simple elements, the learner left her task with a sense of progress and encouragement and returned to it with interest.

Why Men Quit Their Jobs.—A few brief paragraphs may be devoted here to a topic which could hardly be adequately treated in a volume, with the purpose of suggesting a line of thought which may be followed farther if desired. Why do men work and what are the causes which bring them to their tasks with the spirit of driven things, or the spirit of interest and pleasure? The obvious element is the money earned, an essential to existence and the gratification of all men's desires. Back of this, however, lie many factors which are only vaguely realized, if at all, in the man's conscious and subconscious self.

One of the powerful motives certainly is the sense of mastery and the allied sense of security. It is an old saying that it is the poor workmen rather than the good who is a chronic trouble-maker. The man who can do an artistic job of bricklaying, or of fine tool making, is usually also contented with

his position in life. It is the poor workman, who instinctively seeks to divert attention from his work, who makes trouble. The value of training men to become good mechanics is here apparent.

Security was mentioned—another of the keystones of the house of good will and happiness. The prospect of unemployment, the fear of not making good, tear savagely at a man's heart. There are few experiences under which it is harder to hold up one's head and keep one's courage than to be out of a job without anything laid up. Remedial policies have been touched upon elsewhere.

Social esteem and recognition are a third of the keystones. Appreciation of good work, merited praise, are coin of the realm when well bestowed, nor need the fear of encouraging false confidence in the employee's indispensability prevent the judicious use of praise. The social esteem of his fellow-workmen and neighbors is even more vital to the workmen. Here we must respect his class feeling and work with it rather than against it. Petty affronts, quarrels with foremen in which the men may have taken an untenable position but will quit rather than back down, are illustration of the negative application of this motive.

Is there a monotony factor as a cause of labor turnover? Unquestionably there is, yet it varies much with different men. There is a type of man, often very capable, who cannot do even varied and responsible work for long periods without restlessness. Such men are seldom found taking monotonous work save as a last resort. The tramp printer of legendary fame illustrates the type, found high and low. Probably the majority of men prefer monotonous work, with its soothing lack of responsibility, of new decisions. A man may put on one bolt all day long, day in, day out, but he is working with a congenial gang, his thoughts run to and fro from the job to other things, and there is always the stimulus of working to a mark. The mind quickly masters the repeated task and takes it out of the level of conscious thought

to the lower levels of subconscious and automatic or habitual action.

Much more exacting is such work as clerical or routine accounting work, in which there is no opportunity for independent or even novel thinking, and yet no way of relaxing the attention.

Probably a large proportion of labor turnover outside of definitely leaving for a better job or some other good reason is due to what in psychology is called a "complex" of one sort or another. Often it is the inferiority complex—a man feels he is not making good, and gradually becomes so obsessed with the dread of the task to which he thinks he is not equal, that he comes to hate going down to work in the morning. Finally the burden becomes so heavy that he drops it from his shoulders, to try again somewhere else. So also may the sense of social inferiority react with envy and other factors to make a man dissatisfied with a job, which does not pay enough to enable him to spend as do others of his friends. Usually the decision to quit is the final result of a slow gathering of tensions of which the man is himself not fully aware even when the break comes.

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CHAPTER XIX

ORGANIZATION AND EXECUTIVE CONTROL

ALL organization originates from the need to subdivide work which has become too great in volume or too complex for one man. As the business of the individual proprietor increases, he secures assistants as employees or partners and assigns to these men the work which he feels may be most safely intrusted to subordinates, or which he is himself least qualified to perform. The need for frequent changes in assignment of duties, the direct personal contact of the proprietor with all the important facts of his business and the variety of interests which engage his attention, all tend in the small organization to obscure the need for a really systematic and logical division of duties, while they at the same time reduce the seriousness of the results of any mistakes which may have been made. Although there is just as much reason for correct organization in the small business as in the large one, the problem of organization usually does not emerge as such until, by reason of the increasing complexity of operations and increasing remoteness of the proprietor from operation, it becomes impossible longer to effectively operate with a makeshift and structureless organization.

Classification and Division of Duties.—In the process of subdivision of duties there are numerous *points of division.* The proprietor and manager first selects his department heads, as the superintendent or factory manager, the sales manager, the financial and accounting man, and such others as the case demands. Each of these men in turn is faced with a question of division of his duties, and similar points of division occur with every succeeding delegation of duties. It

is evident that a plan of subdivision with might be advantageous for the first point of division (say the usual functional division into the specialized departments of sale, manufacture and so forth) might be wholly inadvisable at one or many of the succeeding points of division. Thus the sales manager would have the choice of dividing his sales field into territories, in each of which a salesman or district manager handled all the company's lines, or he might send out specialty salesmen, each of whom sold only one line, but covered the entire geographical field. The factory manager in turn has a wholly independent problem in the choice between the plans mentioned in Chapter VII of grouping machines into departments by product, each department being an independent or divisional producing unit, complete in itself, or of grouping machines by process, all machines of one function, as lathes, being brought together into a department.

Evidently, while a particular management may lean predominantly toward one or the other type, we cannot speak of an organization as wholly functional or wholly divisional. The decision will have been made between the two types, independently, for a multitude of points of division. Here it will be functional, there divisional, but in each case the facts of the single situation or point of division will have been independently examined.

Functional and Divisional Plans.—These two contrasting general plans of subdivision of duties, stand out as organization types which occur in a great variety of forms and modifications. In the *functional plan,* duties of *like kind* are grouped into a department. The first subdivision of duties is usually of this type, all the accounting work going to one department, that of selling to another, that of manufacture to another, and so forth.

The second of these general types, by analogy with the divisional plan of the railways, may be called a *divisional plan.* In this plan, instead of a group of specialized departments which together perform the whole work of the firm,

we find rather a series of divisions, each in a large measure a *smaller replica* of the original organization. Each is equipped, for one territorial or product or other division of the total operations, to perform all functions independently. An illustration of the divisional plan would be found in the case of a company with foreign branches, each of which had its own accounting, production, sales, and perhaps financial organization, each branch being in large part a replica of the original organization. Usually with this type some one or more functions are retained by the central organization. General executive control practically always is thus retained; financing, accounting, and selling are often retained. But within the group of functions to be divided, the line of division is geographical instead of by function.

An interesting example of the application of a functional distribution of duties at one important point in the organization is Taylor's proposal to divide the work of the foreman on a functional basis. A functional subdivision in this precise form is not in common use because of the difficulty of coordination of the work of the bosses, and other difficulties, but a modified form is now in general use (as described in Chapter XVI) in which the various functional departments clear through the gang boss, who thus acts as a point of coordination, and provides the undivided authority desirable in handling men not highly trained in organization activities. Figure 62, Chapter XV, shows comparatively, the old line type, Taylor's proposal, and the modern modified functional plan of foremanship.

The comparative advantages of the two types have already been discussed in Chapter VII, as they refer to the question of machine departmental layout. Generally speaking the functional type possesses the following advantages:

(1) It permits of subdivision of duties which:
   (a) Reduces tasks to the compass of the ordinary man's capacities.

(b) Permits the separation of skilled and unskilled operations, making possible the reduction of number of skilled men needed.

(c) Makes possible, by concentration of one man on a single task, greater skill and the formation of more definite operation habits.

(2) By centralizing duties of one kind at a particular point the functional plan:

(a) Makes possible an improved load factor or steadiness in the use of the equipment or employee's time.

(b) Provides a volume of work which makes practicable the use of auxiliary facilities.

On the other hand the divisional type has the great advantage of giving an operating unit which is smaller and more compact. While this is obtained at the sacrifice of specialization and quantity production methods, it has advantages as follows:

(a) The breakdown of one unit does not tie up the whole organization.

(b) Problems of coordination are simpler. In the functional department we have a group of specialists, of whom very few have a clear and dominant idea of the final purpose of their activities. As is so often the case in the government bureaus and department, the specialist is interested in advancing his department, even at the expense of the whole.

(c) Because there are more department heads who have the executive instead of the specialist's viewpoint the divisional plan provides a better training school for executives.

(d) Travel and lost motion are reduced because of the greater compactness of the divisional unit. There are less interdepartment orders, accounts, and

communication. To perform a given task it is necessary to set in motion a smaller mechanism than in the case of the functional type. Because of this, emergency action is more prompt in the divisional plan and this plan is clearly the best suited for covering a wide flung, sparse territory, in which the expense of travel and communication becomes large.

This problem of choice between the two plans of subdivision is met in a large number of practical problems. The problems of machine layout, of foremanship, of sales management, have been mentioned. Other examples at random from hundreds of possible ones are these:

To what extent is it desirable to split up the operations in a particular job, say an assembly? Shall we let one man assemble complete, or shall we break up the job into a group of operations? Shall ledgers and stock records be posted functionally, one clerk posting one type of item (as the filled requisitions) for all ledgers, or shall each clerk do all the work on a section of the ledger (say the A to D items). The same problem arises in the stock room. Shall stock men be assigned to sections of bins, or shall one man or group put in receipts, another fill requisitions, etc., for all bins? Another problem arises as to cost and other statistics—shall each major department have its cost and statistical men, or shall this work be concentrated in a special functional department, which has its local representative in the various departments? Another problem—shall each department move its own materials or shall we have a functional department for this work? Another important problem arises in the handling of men—shall employment, discipline and promotion be handled functionally, or as part of the duties of superintendents and foremen? In some of the cases mentioned the advantages of one or the other type are so pronounced that one form has come to be generally used, as in the case of employment or

inspection, now quite generally functional in modern plants. Yet even here the question comes up as to just *which* duties shall be functionalized, which left to the local operating unit. Shall the foreman be allowed, for example, to discharge, or only to suspend? Every point of division and every duty to be divided is a question in itself, to be settled independently.

Figure 70 shows how a sales department would look under each of the two plans.

As a general rule the functional organization seems best to adapt itself to duties which occur with sufficient volume and regularity to allow of reduction to a routine. When a man can be taught a routine, and provided day after day with a volume of work of the same sort, the functional type is unexcelled. Where adaptability, independent action, frequent change of method are necessary, the advantages of functionalization become less and those of the more compact and self-contained divisional unit are greater.

Standardization.—A second question of organization which is met in factory organization is that of standardization. It evidently is a necessary prelude to functional division of duties, or to planning, that these duties shall be studied in detail, the best method adopted, and all variations of method, except the one standard, be discarded. Records will be made where necessary, describing this standard in sufficient detail so that it may be reproduced with certainty and independently of any one man's connection with the organization. Without such fixed standards, uniform, interchangeable, predictable, accuracy in planning and coordination of the functional activities of an assembly crew, or of a functionalized control organization would be impracticable. The work of standardization is simple in theory but often costly and arduous in practice. In the unstandardized shop hundreds of variations in method or even in product will be discovered, and the work of standardization involves not only finding out what is best—a process involving an inconceivable amount of drudgery, often taking years where many products are made—but it involves

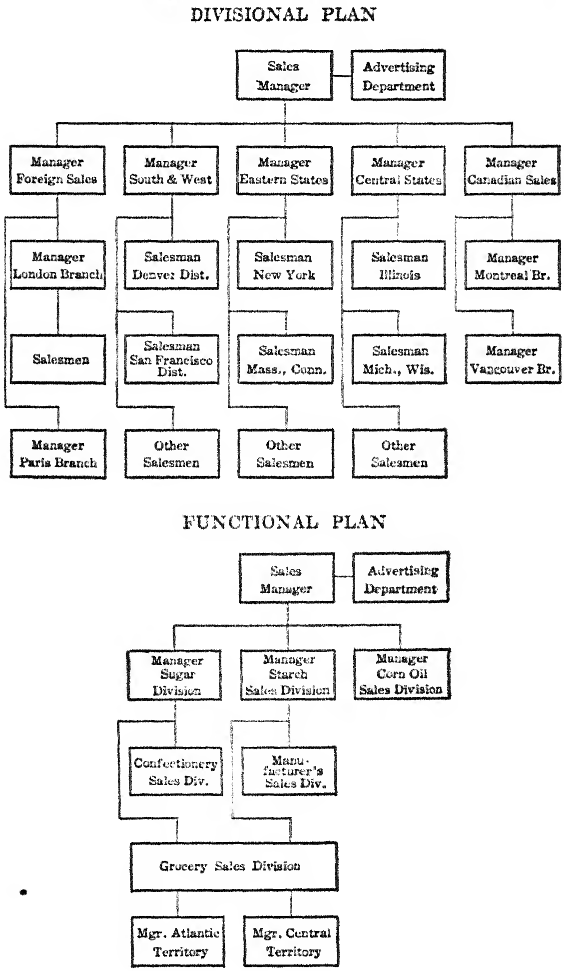

FIG. 70.

CONTRASTING METHODS OF DIVISION OF DUTIES.

also the slow process of reforming habits and teaching the organization the standard method. Examples of fields for standardization have been met in the discussion of planning and scheduling, of rate setting and motion study, of operation layout, or standardization of purchased materials, in the departmental financial budget and in standard costs, in all systems and paper work, in the organization diagram and manual of duties, in the job analysis, and in fact in most departments and problems of the factory.

Centralization.—A third question of organization involves another angle of the question of subdivision of duties. Closely related to the question of functionalization is the question of centralization, since functionalization usually, although not invariably, implies a degree of centralization and is often one of the advantages of centralization.

Two questions as to centralization arise at each point of subdivision of duties. The first question is, between the executive who must delegate and the duty to be performed, how many intermediates shall be provided? Under the superintendent shall we have twenty foremen directly or shall we have four intermediate general foremen, each responsible for five foremen? This is evidently a question of the capacity of the superior and the demands made on him. If each of the twenty foremen is in charge of the same sort of simple duties, as perhaps in the case of labor gangs, the superintendent may be able to handle the twenty directly, at less expense and with better results than would be possible through intermediates. But if each foreman brings up a different set of problems, many of them complicated, the burden necessitates subdivision.

A second aspect of the problem of centralization is the question as to which duties shall be delegated, which retained centrally. Here the general rule is that the central executive's greater experience and ability and grasp of the situation shall be utilized to the maximum by bringing to him only the important and general policy decisions. He lays down the limits

of action set by the policy. Within these limits the subordinate elaborates and works out the details, and so on for each succeeding subdivision. A converse of this rule is that matters need not be carried up for decision beyond the lowest executive who has a control and grasp of all important elements in the decision.

Another method of utilizing general executive ability to the utmost is the use of various auxiliary visualizing devices, and of functional assistance, of which the discussion of centralization in planning in Chapter XII furnishes a practical illustration.

Coordination.—Having laid out duties and assigned them to the various functional and divisional subordinates we will have the skeleton of an organization which bears some resemblance to a well designed machine. It is a machine, however, composed of members each of whom has his own sometimes divergent purposes, and his own more or less imperfect idea of the final end toward which his activities are being directed. The directing executive has the double problem of making his men want to accomplish the purposes of the organization, and of keeping them informed as to what these purposes are, so that as the subordinate makes his hour-to-hour detail decision he will intelligently further the common purpose, and not be working at cross purposes. This problem is especially acute in the large functional organization, where it is hard for the specialist to grasp the ultimate purpose of his activities, and especially to preserve a sense of balance which subordinates his work and pet projects to the common purpose.

The problem of making men want to advance the common purpose is one of morale, and its solution involves the intelligent and sympathetic application of the principles, methods, and ideals of leadership.

The problem of keeping their activities in line involves in the first place an adequate system. When a routine of operation is carefully and harmoniously worked out, inspected

and maintained so that each man does things in a specific and predetermined way, his activities will fit into the general scheme even though he has little or no idea of what the scheme is.

For the activities requiring more discretion the problem of coördination resolves itself into one of supplying information. Thus at a daily meeting of superintendents the main elements or points of urgency on large jobs were discussed in common, men received advance information of work for which they needed to plan, pressure was brought to bear on points of delay, difficulties and misunderstandings were discussed and cleared up. Personal conferences, bulletins, classes, house magazines, are a few of many means used to secure the same result of keeping subordinates with discretionary powers informed of the general situation. The clear enunciation and constant repetition of fundamental policies also aids effectively. Thus the mottoes "The Customer is always right," "Harmony in the shop means harmony in the piano," "Service first," "You can trust your neck to the *Doe* ladder," serve to make concrete and traditional, important policies or attitudes.

Organization and Administration.—There are two phases of the work of the managing executive. The first of these is the problem of structure, of creating, developing, and modifying to meet new needs, the relationship and division of duties which serve to produce the organization as an entity at the command of its leader. The second problem is that of administration, of directing the activities of the organization which has been created, of making the plans, reaching the decisions, giving the orders, which move it to action.

The cycle of action involved in administration may be summed up in four steps as follows: (1) Gather information as a basis for action, (2) Decide (the step of scheduling described in Chapter XI), (3) Dispatch, (4) Supervise and follow up performance.

The method by which the executive obtains control over

the facts of current administration may best be understood by considering what are the duties of this chief executive. He is, in the first place, usually an organizer. He it is who decides the structural relations of the organization and selects the men to perform the respective duties.

Following naturally from this comes the duty of correlation. It is the executive who modifies the over-enthusiastic estimate of the sales department, to conform to the safe financial capacity of the firm, or who adjusts and corrects the activities of a department which is going off at some tangent such as unwise economy in salaries of employees. The executive, of all members of the organization, should see the problem of the business and see it whole.

The executive is responsible for final initiative and decision. Others may suggest; he decides, and when others fail to see the need, he it is who must sense the changing market, decide on and put into force the new policy. His is the final responsibility for results, and if others fail he must be ready with the idea or measure necessary to secure results. His preoccupation is constantly with the unsolved problem, the troublesome tangle, the difficulty, the new and the untried. As soon as the answer is found he can delegate to assistants the task of performance, supervising only to see that orders are carried out and to guide the development and check the results of the decision. The executive thus serves as the pathfinder, the reserve force of the organization army. His time, especially in the large organization, should not be occupied with routine duties, but largely left free so that he can throw the full force of his energies into constructive and creative work, or into meeting what happens to be the critical problem of the moment. This does not mean that he will not concern himself with details. Details as symptoms are among the most important of the facts of business, and it is in enabling the executive to quickly pick out and note significant trifles that his earlier routine apprenticeship will add sureness to his leadership. An unconscious tribute was paid to a great store

manager by the clerk who remarked as he passed, "He has eyes in the back of his head."

The executive is also the supervisor. Men need the stimulus given by the knowledge that their work will come under review, that good work will earn praise and reward and poor work blame or penalty. Therefore beneath the preoccupation of the present problem will be a constant attention to the results of performance. Generally the executive concerns himself but little with the smooth running department except for a periodic review and the bestowing of earned praise and promotion on those responsible for success. But he is alert for signs of trouble. The reports and summaries which come to his desk are many of them specially designed for this purpose. The comparison of actual with budget costs of departmental operation, changes in ratio of overhead to direct expense, labor turnover figures if this is a serious problem, reports of spoiled work or lost time, cost figures, summaries of customers' complaints, inventory balances, reports of past due accounts receivable, comparative sales figures by territory and salesmen, each of these is a report specially or incidentally designed to show results of operation and particularly to enable the executive to put his finger quickly on sore spots. In addition to these systematic checks, some executives acquire an uncanny faculty for spotting the man whose uneasiness, evasive replies, confusion, or absence from conference points to conditions which the man unconsciously desires to keep concealed.

Finally the executive is the leader. He it is who is finally responsible for keeping up the belief of the men in their work. It is to him that the organization turns for decision of the apparently insoluble question, for support of the sheer indomitable will to win in times of trouble, and at all times for initiative, heartening praise, or sometimes discerning appraisal and rebuke. Real leadership is not a matter of panaceas. Men sense leadership and love to pay homage to it in the man whose courage, knowledge, judgment, and under-

standing of men day by day prove him equal to the problems and emergency demands of the business.

The system of control by the chief executive will be designed to serve these five ends, of organization, coordination, initiative and decision, supervision, and leadership. There will be first the routine reports of sales of market and financial conditions, of material and sale prices, of costs and results of operation, of unfilled orders, of money requirements, which give him a sort of moving picture of the facts of operation, enabling him to plan and make decisions with all the facts of the current situation before him. Figure 71 is a report received daily by the executive head of a small company and used by him to give him at a glance the general condition of the business.

In addition to these regularly presented reports, selected and arranged to give a running summary of the facts which for the particular business are important, there will from time to time be laid before the executive the reports of those special activities which at the time engage his attention. Perhaps labor conditions are unsettled, and a study and summary will be made showing wages being paid in competitive plants or trades, or showing living costs, if these enter as a factor. Perhaps there is patent litigation pending, and the company's lawyers may go over the company's position and the facts of the case with the executive and with him decide on a course of action. Perhaps the product has proven inadequate to its purpose in some way, or must be modified to meet a new need, and the executive will be listening to his engineers, perhaps himself making practical suggestions of a better material or a new style of finish. These and other subjects will intermittently engage the executive's consideration, assume temporary importance in his program, and as they are solved will again recede.

And finally there will be the supervisory reports of which examples have already been given.

The form and method of the executive's control will be

DAILY REPORT .... 19..

FINANCIAL

Collections
Today ....$....
Month to date........$....

Disbursements
Today ....$....
Month to date........$....

Bank balance
Today ....$....
Obligations maturing within 10 days......$....

Accounts receivable
Balance ....$....
Audited vouchers balance..$....

SALES

Billings today ....$..............
Month to date..........$..............
Orders received ....$..............

Sales by products	*Total*	*Class 1*	*Class 2*	*Class 3*
Today				
To date				

Orders booked

Salesman	*Today*	*Month to date*
1	......	......
2	......	......
3	......	......
4	......	......
Total		

MANUFACTURING	*Orders received*	*Shipments*	*Unfilled orders*
Today			
Month to date...			

Output of Item No.

1	6		11		
2	7		12		
3	8		13		
4	9		14		
5	10		15		

FIG. 71.

DAILY REPORT RECEIVED BY THE MANAGER OF A SMALL COMPANY.

varied to suit his temperament, abilities, and training. The man who came up through the production end is apt to lean toward an interest in manufacturing economies and improved methods, and leave to men he can trust the selling and the

financing of the business. The dynamic leadership type of man is apt to take many of his decisions ready made from his department heads, his strength being in his ability to put conviction, reality and motive impulse into the ideas of others. Another man will secure his mastery by grasp of details, another by shrewd foresight.

Since this book is intended as a general description of the problems of factory organization and management, little has been said about the problems of technical method and of policy, which necessarily differ in specific industries. A good chemical formula or a correct mechanical construction, knowledge of just the right temperature for making a paint or tempering a tool, or ability to secure pleasing or fashionable design, may be fully as important to the success of the enterprise as is correct organization. And similarly a sound credit policy, a correct selling distribution plan, a good advertising idea, a knowledge of buying markets and source of supply—any one or more of these things may be the key to success.

These things constitute fields of knowledge as important to the factory manager as the problems of organization and administration here discussed. The attempt has been made in this text to develop the organization side of factory management, and to show the factory as a problem, the various phases of which are capable of orderly and coordinated solution in view of the special circumstances of the case; as a mechanism, in which, intimately bound up with the social and technical problems of production, there is a problem of correct structural relations and operating methods, a technique of management.

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PROBLEMS IN FACTORY MANAGEMENT

In order to give the student convenient material for the application of the principles described in the text, the following series of problems has been added. Naturally it is impossible within the limits of a brief statement to reproduce all the varied and complex factors which affect an actual solution. Some simplification, conventionalization and approximation is inevitable, yet it is believed that even with this qualification the student will find that a conscientious solution of the various problems will immensely increase and clarify his grasp of the methods described in the text, and will, if the testimony of many former students who have worked out these problems may be believed, be of real help in indicating how the problems of the factory may actually be approached.

The problems are grouped by chapters and one or all of the problems for a chapter may be worked out, depending on the amount of time available. It will be noticed that many of the problems are grouped around a little spring factory, forming a series in which many of the more important questions of factory layout and operation are grouped. It is suggested that preference be given to the problems in this series if a selection is necessary. It would be an easy matter to collect data for a similar series of problems applicable to another industry, if desired. Needless to say, the "Victor Spring Company" is a hypothetical case, yet the data used, while modified, is sufficiently in proportion to be applicable in the main to an actual case, being drawn from the author's personal experience as head of a similar company.

PROBLEMS

CHAPTER I

PROBLEM 1. Briefly define the duties of each department or official shown in the factory organization diagram in Figure 3.

PROBLEM 2. Rearrange this diagram, classifying the officials and departments shown in it, under four headings, accordingly as their duties are primarily of one or another of the four major functions of production. Where an official also has secondary functions, list his title under the secondary heading also, followed by (S).

CHAPTER II

PROBLEM 3. The following are the monthly gross sales of the Victor Spring Company, manufacturers of bedsprings.

January	$10,000	July	$30,000
February	20,000	August	40,000
March	20,000	September	50,000
April	30,000	October	40,000
May	50,000	November	20,000
June	40,000	December	10,000

Assume that the sales are approximately the same from year to year. A condensed balance sheet as of January 1 is as follows:

Assets		*Liabilities and Capital*	
Cash	$19,000	Accounts Payable	$ 3,000
Accts. Rec.	10,000	Capital Stock	100,000
Inventory	17,000		
Machinery and Plant	56,000		
Patents	1,000		
	$103,000		$103,000

The firm's experience shows that it takes an average of one month after sale to collect an account receivable, that on the aver-

age raw material is paid for, two months before sale, labor and general expense one month before sale, selling cost (mainly commissions) in the current month of sale. 30% of the selling price is expended for materials, 30% for labor, 20% for manufacturing and general expense, 10% for commissions and other selling expense. 95% of the gross sales are realized in cash, the remaining 5% representing cash and jobbers' discounts averaging 4½%, bad debt losses ½%.

(a) On the basis of the above figures prepare a budget showing the monthly receipts and expenses and money requirements for the year.

(SUGGESTED HEADINGS FOR TABLE)

Month	*Gross Sales*	*Expenditures*					*Collections*	*Monthly Balance*		*Cumulative Balance*	
		Material	*Labor*	*Expense*	*Sales Cost*	*Total*		+	−	+	−

(b) What would be the capital turnover (ratio of net sales to capital) in this case? What would be the percentage of profit on capital? What would be the load factor of the sales of the business (ratio of average month's sales to largest month's sales)?

PROBLEM 4. Make a comparative analysis, similar to that shown in Figure 5, of the balance sheets of five companies, preferably in the same line of manufacturing. Classify the assets and liabilities as shown in this figure and state them in terms of percentages of net worth, determining also from the total sales, the capital turnover of the company. Explain any outstanding variations in the percentages of particular assets, giving as far as possible the apparent reasons for the presence of any exceptional items of inventory, good will, etc. In which items does there appear to be a degree of uniformity, and in which items do local conditions appear to produce wide variations? What appears to be the standard practice in the case of those items showing uniformity?

PROBLEM 5. Prepare a "circulation of capital" diagram similar to that shown in Figure 6, but including also the following features:

(a) The circulation of money borrowed on note given to a bank.

(b) Separation and separate illustration in the diagram of manufacturing and of selling expense.

Chapter III

Problem 6. Outline the principal features of the distribution plan you consider most effective for the Victor Spring Company, after a brief canvass of your locality as to the type of dealer who carries bedsprings. The factory selling price of the springs may be assumed to be an average of $8.00 each, and the average invoice sold will be $60.00. What would be the possible channels of retail sale to the consumer? What would be the arguments for and against sale by the Victor people direct to the retailer, as compared with sale through an intermediate wholesaler or wholesalers?

This problem may be worked out for any other manufactured product, if desired.

Problem 7. Assume that the Victor Spring Company, as described in previous problems, has decided to sell direct to retailers through travelling salesmen. Assume for the purposes of this problem that it has decided to locate in your home town or a neighboring larger city. Explain the policies you would adopt, and your reason for adopting them, with reference to the following questions:

(a) Advertising—would it be advisable, how would you determine the amount of your appropriation if so? Would you advertise in national or local mediums? How would you tie in your advertising with your selling effort?

(b) Would you sell to one dealer in a locality, centering any local advertising done, etc., around this dealer, or would you sell to any dealer who wished to buy?

(c) How often would you have your salesmen call during the busy season? The slack season?

(d) Would you confine salesmen's calls to the larger towns (say over 10,000 inhabitants) or would you have them make all stops? How would you decide where to draw the line? How would it be possible to keep in touch with dealers in towns in which the volume of business did not warrant regular calls?

Chapter IV

Problem 8. A description is given (page 63, Chapter IV) of the steps taken in filling a customer's order in the men's clothing industry. From this description prepare a course of the order diagram, in which, following the method illustrated in Figure 12,

the steps in filling an order in this industry are shown in full detail.

Problem 9. A certain toy company manufactures several lines of toys, including a set of turned blocks and rods from which the child can construct bridges, windmills, etc., also several styles of jointed and mechanical dolls made principally from turned wood. Several thousand gross are made of the principal line, and from this number the output ranges down to a few hundred sets of some of the less popular toys. Parts are bought ready turned from another factory, but are put through a few finishing processes in case of one of the products. The general plan of organization is to keep a few men busy on the miscellaneous finishing and unit parts processes needed, and to divide the bulk of the remaining operators into separate assembling crews. Each crew works at one product either continuously, in the case of the larger items, or continuously until one lot is finished, then on another lot, in the case of small items. An estimate is made up each year of the number to be made of each item, and the factory seldom varies from this estimate, most of the goods being made up in advance for the Christmas trade. In addition to the part finishing and assembling processes, all parts pass through a painting room, where colors are applied by dipping and by stencil.

(a) Classify this industry as to its general correspondence at various points with one or another of the three typical cases described in Chapter IV.

(b) Prepare a course of the order diagram indicating the principal steps which would be taken in filling customers' and stock replenishment orders.

Chapter V

Problem 10. Figure 20, Chapter V, is a table of the parts and operations necessary in the manufacture of bedspring model No. 441, one of the principal products of the Victor Spring Company. The steps taken in manufacture are in general as described in Chapter V, the unit parts being first made, the base or slat, composed of angle and band iron, being next assembled, and the spring superstructure in turn assembled on the base. Figure 19, page 71, is a photograph of a completed spring, of the unit parts, and of an assembled base with one spiral set up.

The company plans to equip department *A* for the continuous manufacture of this model at the rate of 120 complete springs per ten hour day. Prepare an analysis showing:

(a) The machine-hours per day required for a balanced production of this output.

(b) The machines which would be necessary for the department. (Some of these would be in use only a fraction of the working day, since the output is small.)

(c) Since many of the operations require fractional days, one or more day's run would probably be made up and put in stock at intervals, allowing one man to alternate between two or three operations, working a full day at each. Thus one man might work in a cycle of five days, spending three days of the five on operation No. 1-B2 and two days on operation No. 1-B3. Work out similar groupings where possible for the other operations, indicating the number of men required at each and the total direct labor force. The following groups of operations may be considered as interchangeable, an employe in any group being capable of performing any of the operations in the group: Group 1,—1-B1, 1-B2, 1-B3, 2-B2, 2-B3. Group 2,—1-B. Group 3,—1. Group 4,—1-S. Group 5,—2-S, 1-D, 1-CB, 1-CT. Operations 3 and 5 may be done by any available men.

Problem 11. For the toy company referred to in Problem 9, what method would you use for making the operation analysis or routing of a new product? Prepare a suitable form to use as a route sheet or record for making such studies and preserving them as standards.

Chapter VI

Problem 12. Visit three or more industries of various types, such as the following: job or newspaper printing shop, machine specialty or jobbing shop, shoe factory, garment shop, bakery, brick, tile or pottery factory. From personal observation and questioning of the management (or other available sources of information) prepare in comparative tabular form a report covering the following points:

1. Name and address of company.
2. Product manufactured.
3. In order of importance what were the principal factors which led to the choice of the present location as to general section of the country, and particular locality in the city or town?
4. Of what type, or types, is the industry as regards flow repetitive, lot repetitive, or special order plan of manufacture?

5. How does the nature of the process from this standpoint affect the type of building, arrangement of machinery, and method of handling materials?
6. What special fire protection features were noticed?
7. What special material moving devices were used?
8. From what source is power secured and how is it transmitted to the machines?
9. Does the general course of the order and plan of manufacturing control and replenishment correspond to the first, second or third type described in the classification given in Chapter IV, Fig. 15?

(NOTE: Similar outlines for factory inspection trips may profitably be prepared and used to study and summarize typical procedure as to Shop Layout, Material Supply, Planning and Scheduling, Cost Finding, Labor Management, etc.)

PROBLEM 13. The A & B Piano Company, located in Detroit, Michigan, receives an offer from the Chamber of Commerce of Grand Haven, Michigan (a town of about 15,000 located on the eastern shores of Lake Michigan), of a free factory site and a building loan if the company will move its factory to Grand Haven. The company has contemplated building in any case.

Grand Haven is 150 miles by rail and one night by boat from Chicago, and is also served by one steam railroad, the Pere Marquette, and by an electric interurban line. Wages are lower than in Detroit, and the town has a number of other factories, some of which are in woodworking lines.

The A & B Piano Company employs 1000 people, of whom about 300 are skilled piano makers, tuners, foremen, etc., many of whom have their homes in Detroit. Employment is as a rule fairly steady, but in dull seasons a third or a half the force is sometimes laid off. The company advertises its produce nationally, selling principally in the middle west. About 15% of its trade is in Detroit and its immediate environs.

What problems would be raised if the offer were accepted? What advantages would accrue? In your opinion, would the move be desirable? Give your reasons.

PROBLEM 14. Assuming that the net profit on an article manufactured in your home town is $2.00 per article, that each article weighs 100 lbs., takes the first class, less than carload, freight rate and is sold F.O.B. destination, prepare a map showing the limits of profitable sale of the article from the standpoint of delivery

costs. Information as to the rate to various neighboring cities of over 5000 population may be obtained from the local freight agent or from the published schedules of tariffs, and by plotting these rates on a map, a line may be drawn connecting the points at which transportation becomes a limiting factor.

Chapter VII

Problem 15. The following table indicates the space requirements for the machines used in making bedsprings No. 441, referred to in Chapter V.

Machine	*Machine- and Working-space, Feet*	*Piling Space for Current Work in Process, Feet*
Oven	10 x 30	......
Tank	10 x 20	20 x 20
(Oven and tank must be placed end to end with a dipping space 10 feet square between them, in a separate room with fireproof partitions)		
Crating machine	10 x 10	20 x 20
Riveting machine	10 x 10	10 x 10
Gang press	10 x 20	10 x 10
Bending machine	10 x 10	10 x 10
Coiling machine	10 x 10	5 x 10
Knotting machine	5 x 10	10 x 10
Crimp machine	5 x 10	5 x 10
Forming table	10 x 10	5 x 10
Final assembling bench	10 x 10	......
Shop office	20 x 20	......
Shipping space	......	20 x 20
Storage space, raw materials, 1,000 square feet, any shape.		

Motors will be overhead and machines should be grouped so that the base or slat making machinery operates from one shaft, the wire making machinery from another. Main aisles will be about 8 ft. in width, cross aisles 5 ft. Assume that the Victor Spring Company plans to build a building 60 ft. in width, one or more stories high as needed, lighted from both sides and ends, with a switch track at one end, and a street adjacent to one side. There will be three rows of columns, spaced 15 ft. each way.

Space will have to be provided to store a reserve stock of 15 days'

assembled springs, which will be put into stock before enameling, being enameled just prior to shipment. A completed spring is approximately 6′ 2″ x 4′ 6″ x 8″, and the springs can be piled two deep on the 6′ 2″ edge. Cross aisles in this storage space need not be over 3′ 0″ wide. The majority of springs made will not go into stock, but will be shipped direct on orders.

On the basis of the above information, using templates as described in Chapter VII, prepare a suitable plan for the building, and placing of equipment for the "441" department. Make suitable provision for stairway and elevator if these are required, also for washroom, men's lockers, etc. Mark out the floor plan to scale on cross section paper and cut the machine templates out to the same scale. Indicate the path of movement of the materials by a distinctive line, from receipt of raw material to loading of finished springs into the car.

Problem 16. In addition to the "441" spring department (Dept. A) of the Victor Spring Co., it has another department (Dept. B) manufacturing a variety of other springs. Three general styles of construction are used, the main features of difference being in the construction of the upper surface of the spring. The base and spiral springs differ only in dimensions and pattern for the various models, being basically the same in each model. These springs are also made in special widths to customer's orders when desired.

(a) How would the arrangement of machinery in this department differ from that in the "441" department referred to in Problem 15?

(b) What would be the advantages or disadvantages of the use of the "product" plan of machine grouping in this case? Of the "process" grouping? Which would you use?

Problem 17. Visit a manufacturing establishment and make a list of all the processes, either in the factory as a whole if small or in the production of some particular part or product, and classify these operations in accordance with the process classification outlined in Chapter V, pages 81, 82 and 83.

Chapter VIII

Problem 18. The following table indicates the time required for addressing envelopes on the typewriter, the operations being analyzed and timed as shown in the table.

Operation Cycle No.	Elapsed Time in Hundredths of a Minute. Insert envelope.	Write 1st line.	Write 2nd line.	Write 3rd line.
1	.06	.07	.08	.07
2	.14	.08	.06	.05
3	.08	.05	.06	.06
4	.13	.05	.08	.05
5	.09	.06	.07	.07
6	.09	.05	.07	.06
7	.08	.05	.07	.05
8	.10	.05	.07	.08
9	.10	.06	.06	.07
10	.09	.04	.09	.08

Derive the standard time for the operation of addressing an envelope, using the Taylor system and making an allowance of 30% for fatigue and interruptions. Ascertain normal or modal time as explained in Chapter VIII and compare results.

PROBLEM 19. Make a time study of the operation of writing a letter and addressing the envelope on the typewriter, covering the following points:

(a) Describing the proper placing of machine, paper, envelopes, finished work, seating of operator, lighting, etc.

(b) Dividing the operation into elements suitable for timing, and taking at least ten complete cycle readings on letters of different lengths.

(c) Deriving a formula for the standard time (1) of writing the heading and envelope and other constant elements and (2) per square inch, or number of lines, in the body of the letter. (Each of these methods of measuring typing is in fairly common use in office work, number of square inches in a letter being measured by a ruled celluloid stencil laid over the body of the letter, number of lines being recorded by a "cyclometer" which records each movement of the platen back to starting.)

Use a stop watch divided in hundredths of a minute if available, otherwise read the second hand of an ordinary watch.

CHAPTER IX

PROBLEM 20. Prepare a set of forms and outline a procedure in purchasing, suitable for the Victor Spring Company.

PROBLEM 21. The Victor Spring Company, Chicago, Illinois, is considering buying band iron (See Problem 10) in carload lots.

Assume that its requirements of 1", No. 12 gauge (gauge refers to thickness) mild band steel, 16 feet lengths, will be 6,000 lbs. per month.

This material may be bought F.O.B. Pittsburgh in carload lots for \$2.90 per 100 lbs., freight \$.38 per 100. In less than carload (L.C.L.) shipments an extra of \$.15 per 100 lbs. is added by the manufacturer and the freight is \$.48. A minimum carload is 36,000 lbs. Mill orders must be placed ninety days before delivery and to equalize irregularities in shipment a reserve stock of forty-five days' supply is carried. Unloading from car to factory adds \$.02 per 100 lbs. to the price.

If obtained from a Chicago jobber the warehouse price F.O.B. the Victor factory is \$3.70 and a two ton order can be filled on a day's notice, practically no reserve stock being necessary.

The market may be assumed to be steady. The firm is able to earn 15% on all the capital it has or can borrow.

(a) Prepare a schedule or stock limit plan for this item of material and find the comparative costs of the item per month under each of the three plans (Mill Carload, Mill L.C.L., warehouse) of supply.

(b) What conditions in addition to those here named might influence your choice between mill and warehouse buying?

(c) Which plan would you favor, and why?

CHAPTER X

PROBLEM 22. Assuming that the Victor Spring Company operates the two departments referred to in Problem 16, outline a suitable plan for storing and issuing raw materials and work in process, designing suitable forms where required. Cover the method of stock record, of inventory, of issue of materials for production, of pricing materials, of handling punchings and other salvaged scrap, and the personnel of the department.

PROBLEM 23. Prepare a stock record form suitable for record of apportionment to customers' orders and make the entries necessitated by the transactions shown below.

Article—Angle iron side rails 1¼" x 1¼" x ⅛", extra long (5'-10"). Weight each—6 lbs.

Symbol—441-B1 special. Minimum 50. Quantity to order 100.

Sales or customers' order numbers are indicated by prefix "S". Indicate necessary purchase order numbers by prefix "P". Assume

that purchase orders will be filled in 20 days. Present market cost is \$2.05 per 100 lbs. First new purchase order number will be P128.

January 1.	Closing balance 66.
January 1.	Inventory shows 65 on hand, of which two are defective.
January 28.	Customer's order S941 calls for 10.
February 4.	Customer's order S980 calls for 110, for a special lot of institution beds.
February 16.	Order S941 filled.
March 3.	Three drawn from stock to replace spoilage on S941.
March 11.	Partial requisition (for 60) on order S980 filled.
April 2.	Customer's order S1004 calls for 18.
April 5.	Order S980 reduced from 110 to 100, the institution finding that it had some extra beds available.
April 12.	Order S1120 calls for 24.
April 12.	Balance of order S980 filled.
April 16.	Order S1004 filled.
April 24.	Bin tag turned in to office shows 130 on hand.
April 25.	Order S1226 calls for 80. This is a rush order, for immediate delivery from stock.
April 30.	Order S1321 calls for 25.
May 1.	Order S1120 filled.
May 14.	Order S1321 filled.

Problem 24. What considerations would determine whether or not the stock limits set for this item are correct? Assuming a slightly rising material market, and a seasonal business such as that indicated in Problem 3, are the limits as now set correct? If you believe they are not, how would you change them, and why?

Problem 25. Prepare a stock record card suitable for the recording of steel angle stock for a steel warehouse, apportionment not being necessary. Angles of any given size are carried in stock in standard lengths, 10 ft., 12 ft., and by 2 ft. additions up to 20 ft. Short and odd lengths are often left in filling customer's orders. These must be used up as rapidly and with as little waste as possible in filling subsequent orders.

Chapter XI

Problem 26. Assume that the manufacture of a lot of 400 of bedspring 441, for which an operation analysis is given in Chapter V, is going to be undertaken by a miscellaneous jobbing spring shop, which, not being regularly equipped for bedspring manufacture, has available only one of a kind of the necessary machines and benches. Disregard in this problem any other orders in the shop and assume that the available capacity of these machines will be available for this order.

Assume a ten hour day, five hours Saturday, no work Sundays or holidays.

On these assumptions prepare from the data given in Chapter V an assembly diagram showing the necessary starting time for each operation, in order to ship the completed order of 400 springs on the morning of June 1st. Assume that necessary allowances for delays and contingencies have been made in the operation times given.

In working this problem either of two further assumptions may be made:

(a) That one operation will be completed on the whole lot before the next is started.

(b) That work on a subsequent operation may be started as soon as enough parts are finished on the preceding operation to allow the subsequent operation to proceed to completion without being interrupted to wait for material. (a) is the simpler assumption to schedule and is the one usually found in the variety industry where many small orders, rather than a few large ones, are being handled.

Problem 27. (a) Prepare a diagram showing machine control board suitable for the use of the job spring shop referred to in Problem 26, and on this board schedule completely the operations as shown in the job program of the assembly diagram of Problem 26.

(b) Describe the method by which such a job would be analyzed and scheduled by the Taylor planning board system. Using numbered three-compartment squares in a diagram to represent a Taylor board, schedule the operations on the base or slat parts (441-B and its unit parts) as they would appear at the commencement of the job. (Indicate the placing of the various job instruction cards in the proper pockets by noting the operation number in the proper compartment of the diagram.)

(c) Under what circumstances would it be advisable to schedule this job according to the method used in (a)? What objections would be likely to be found in a job shop to the use of this method? In what ways is the "paper scheduling" done in this problem similar to, and in what ways different from the actual work of a schedule clerk?

Chapter XII

Problem 28. The operations involved in production planning and control may be classified under the following headings:

(1) General controlling sales estimate or production schedule or budget.
(2) Control of stock replenishment.
(3) Operation analysis or routing.
(4) Scheduling
  (a) The job schedule or order program.
  (b) The machine schedule or shop program.
(5) Dispatching.
(6) Progress record.
(7) Follow-up of performance.
(8) Systems of supplying materials, tools, working drawings, etc., to the workman at the time of or in advance of operation.

For each of these operations a variety of devices and methods are in use in different situations, such as the various types of route sheet described in Chapter V, or of progress record in Chapter XII.

Prepare a list, classified under the above headings, of all the devices and methods named in the text, or which you have found in reading or observation, used in the accomplishment of the purpose named in the above list. Briefly describe any named by you and not described in the text.

Problem 29. Prepare in your own words a statement of the problem of centralization in production scheduling, giving a working rule for the degree to which, in any particular case, it is necessary to carry decisions as to schedule up to a central point in the organization. Describe also the devices by which, for a given necessary degree of centralization, the scheduling executive is assisted in adequately making his decisions. Classify these devices under the headings: (a) Devices for functionalizing the executive's work, (b) devices for visualizing the facts of the situation, (c) de-

vices for decentralization of detail with retention of final central decision and supervision.

Problem 30. What would be the advantages respectively of a highly centralized control such as that of the Franklin plan, and of a decentralized plan such as that described in Plan No. 6, Chapter XIII? Put in the form of a general rule a statement of the conditions in an industry which would make it advisable to tend toward centralized or decentralized control.

Chapter XIII

Problem 31. Work out and prepare illustrations of the necessary forms and devices for a simple scheduling system for the Victor Spring Company factory described in previous problems.

(a) For the repetitive "441" department A, with employes of the number determined in Problem 10.

(b) For the "miscellaneous order" department B referred to in Problem 16, about forty people being employed in this department, and there being at any one time an average of one hundred orders, ranging from one spring to two hundred springs each, on the books.

Cover in your solution to this problem the method of handling (omit where not necessary) each of the operations in production control listed in Problem 28.

Problem 32. Classifying them according to the list given in Problem 28, prepare as extensive a list as practicable of the use of the devices of planning and scheduling in fields other than factory production control—such fields as office, mercantile, and sales management, ordering of one's own personal affairs, government and military control, and other fields of human activity. Show how the same principles of centralization, standardization, etc., used in factory scheduling apply in some one of these fields.

Problem 33. Summarize in a comparative table the principal characteristics of the flow repetitive, lot repetitive and special order industries as to each of the following topics: Product design, process design, stock limit control, scheduling of machine capacity or program, control of movement of materials, method of providing workmen with operating instructions, progress record, follow-up of production processes, plan of machine departmentalization, skill of workers required, relative amount of supervision and clerical

work necessary, relative size of inventory of work-in-process and finished stock, relative amount invested in machinery.

CHAPTER XIV

PROBLEM 34. In department "B" of the Victor Spring Company the following is the record of expenditures on order S281, 100 springs:

Operation Number (See Chapter V	*Material Cost*	*Hours Taken*	*Man's Rate per Hour*	*Machine Rate per Hour*
1-B1	$15.00	2	$ .45	$ .50
1-B2	30.00	5	.45	.50
2-B2	....	3	.45	.20
1-B3	5.00	3	.45	.50
2-B3	....	3	.45	.20
1-B	....	20	.60	.20
1-S	80.00	10	.60	.30
2-S	....	20	.50	.15
1-D	10.00	2	.60	.10
1-CB	20.00	3	.60	.30
1-CT	20.00	3	.60	.30
1	....	50	.75	.10
3	Paint 15.00	3	.45	.10
1 and 4......	Gas 1.00	3	.45	.20

In addition to the departmental burden taken care of by the hourly machine rate there are the following charges: undistributed and general administrative burden, $.10 per labor hour; selling expense 10% of factory cost. The total number of hours worked averages 12,000 hours per month. The total factory burden including the items named above averages $6,000 per month.

Ascertain the cost of this order: (a) using the machine rate method of distribution indicated in the problem, (b) using the labor hour method of expense distribution.

PROBLEM 35. (a) Which of the systems of collecting cost figures described in Chapter XIV would you consider best adapted to ascertain costs in departments "A" and "B" of the Victor Spring Company respectively? Which for the jobbing shop referred to in Problem 26? Give reasons in each case.

(b) What system of expense distribution, and why, would you

use in each of the above cases? (The machinery used in unit part making, coilers, gang presses, etc., is relatively costly. The assembly tables are very inexpensive. In department B, unit part machinery will be used to a variable extent on different models, many of the unit parts being purchased for one of the models, a flat fabric spring.)

PROBLEM 36. Work out the forms for a suitable cost system for department B of the Victor Spring Company according to the plans formed in Problem 35. Prepare a course of the order diagram illustrating the steps taken in using these forms in the collection of costs.

PROBLEM 37. Prepare a standing expense order card for the accounts for which provision would probably have to be made by the Victor Spring Company in properly ascertaining the results of operation. Prepare for this list a system of standing order numbers, worked out systematically on the basis of a decimal system similar in principle to the Dewey decimal system, or on the basis of a mnemonic symbolization such as described in Chapter X.

CHAPTER XV

PROBLEM 38. Prepare score cards naming and giving proper weights in a total of 10 to the qualities you would consider in judging or rating foremen for departments A and B of the Victor Spring Company.

PROBLEM 39. Outline the procedure which, as foreman, you would take in handling the following typical disciplinary problems in the shop: The habitually tardy employee. The employee who believes that "pull" is worth more than good work in securing promotion in the particular factory in question. The employee who is discontented with his work but is not capable of holding a better job. The man who has lost ambition and does just enough to hold his job. The "agitator" who always leads the demand for higher wages or who is attempting to organize the men against the company.

CHAPTER XVI

PROBLEM 40. Outline a simple plan for Labor Management of the Victor Spring Company, indicating the main functions for which provision would be made, and the members of the organiza

tion or specially hired employees who would be made responsible for the performance of these functions.

PROBLEM 41. Prepare a set of forms suitable for the employment department of the Victor Spring Company.

PROBLEM 42. Prepare an outline for an apprentice training course designed to develop shop foremen and executives, specifying such points as the following: Length of course, age and educational preparation of accepted applicants, type of contract entered into, compensation of apprentices, course of shop work you would lay out (for example in a machine shop or similar industry), class work, including time per week in classes, time of day at which classes would be held and studies pursued. Supervision of program of apprentices. Vocational advice to apprentices. Method of keeping track of progress of the apprentices.

CHAPTER XVII

PROBLEM 43. The standard time for assembling a bedspring for a team of two men is one half hour (Figure 20, Chapter V). The day rate for workers of this class is \$.60 per hour and the usual additional earning figured in piece rate is 20%.

Compute the team's earning per hour, and the cost per piece, under each of the following systems: day wage, piece rate, Halsey premium, Gantt bonus, and for each of the following times per spring: forty minutes, thirty minutes, twenty minutes. In case of the Halsey system assume that the standard time is set as thirty-six minutes to encourage production and that the saving over standard is divided equally between management and men. In the case of the Gantt system assume that a bonus of 20% is paid for completion of the work in standard time ($\frac{1}{2}$ hour), the worker in this system being paid for standard time plus 20% no matter how much less actual time is than standard, and being free on the completion of one job to start the next.

CHAPTER XVIII

PROBLEM 44. Diagram the procedure of the International Harvester Works Council plan as described in the text, showing the steps taken in making or appealing a claim, in a fashion similar to that in which Figure 69 is constructed.

PROBLEM 45. Prepare a list of the points which should be covered by a works council plan and briefly indicate what you would regard as good practice in handling each point.

PROBLEM 46. Including the field of labor management but going beyond this into the broader field of works management, prepare a list of those conditions of employment and shop management which you consider of the greatest importance in maintaining shop morale, interest and loyalty—the things you yourself, as an employee, would consider important in deciding whether to take the job. Assign approximate weights to these factors and construct a score card to be used by the employee in rating the desirability of his job.

CHAPTER XIX

PROBLEM 47. In an automobile motor manufacturing plant it is at present the custom in assembling motors for a crew of two men to draw out all the material needed for an order of motors and assemble complete. The work in this shop is of somewhat varied nature, motors being made up in a variety of types and with special modifications to suit the customer's wishes. Orders vary from one to one thousand motors, about 60% of the total output being on orders of one hundred or more. The average time for assembling a motor by the crew of two men is two hours and forty minutes.

The superintendent has presented for consideration a proposed layout for a progressive assembly "track," which will have twenty-four positions, one man at a position, and on which he estimates from previous experience the total assembling time will be slightly less than two hours.

Compare these two plans as to respective advantages in handling large and small orders, and name the factors you would consider in arriving at a decision as to whether to install the track in place of the present system, to retain the present system exclusively, or to operate both, in the latter case telling how you would determine the minimum size of order which it would be advisable to assemble on the track.

PROBLEM 48. Name the records which you would consider it advisable to furnish the president and general manager of the Victor Spring Company, as a guide in managing this business and determining its policies.

PROBLEM 49. Prepare a list of the more important applications of the principle of standardization in the factory and indicate briefly for each application the manner in which the standard is ascertained and established.

PROBLEM 50. Prepare an organization diagram showing the complete organization you would consider advisable of the Victor Spring Company as described in the previous problems.

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